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EDITORIAL NOTES.

THE Editors have been much gratified by the kind response that they have received to their appeal for the support of geologists both at home and abroad in their endeavour to secure the continuance of the GEOLOGICAL MAGAZINE. Numerous letters have come to hand from all quarters promising valuable assistance, both moral and material, in their campaign against the adverse conditions that at one time threatened the very existence of the Magazine. The Editors felt sure from the beginning that it was only necessary to inform their friends of the critical situation in order to enlist their help, and this confidence has been abundantly justified, so much so that it is now possible to look forward to the future with some degree of assurance, although it is still clear that the margin of safety is not yet adequate to ensure against difficulties arising from a further possible increase in the cost of production. The strictest economy will still be essential in every way. It may perhaps clear the air and avoid any possible misunderstanding if it is generally understood that the editorship is now a labour of love, at any rate in the sense that it is not remunerated. It is hoped that this condition is only temporary, and that it may in a while be possible to revert to the former state of affairs, but at present even a small editorial salary is inconsistent with the continuance of the Magazine. It is, of course, impossible to cater with equal success for all tastes, and the Editors can only do what they think will give most satisfaction to the majority of readers. Although a certain amount of criticism has been received, yet this is far outweighed by the mass of favourable comment coming from many quarters, for which the Editors are duly grateful.

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A SPECIALLY pleasing feature has been the active support obtained from sources outside this country; from the British Dominions overseas, and especially from the United States of America. Kindly letters have come to hand from South Africa, New Zealand, and many other countries where geology flourishes. But the best news of all comes from America. On New Year's Day a cable was received from Boston, stating that the Geological Society of America has guaranteed to find forty new subscribers for the present year. This

great assistance we owe largely to the efforts of our kind friends and contributors, Dr. J. M. Clarke, of Albany, and Mr. P. E. Raymond, of Harvard, to whom we hereby tender our hearty thanks. It is events of this kind that encourage us to carry on in the hope of promoting that worldwide exchange of geological thought which we have so much at heart, and which we firmly believe to be so beneficial to the science of geology in general and to individual workers in particular.

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The Council of the Geological Society has this year awarded its annual Medals and Funds as follows: The Wollaston Medal to Professor Baron G. J. de Geer, of Stockholm, whose work is so well known to all geologists, and especially to glacialists, as to need no further reference here; the Murchison Medal to Mrs. Shakespear, formerly Miss E. M. Wood, the collaborator with Miss G. L. Elles in their great work on graptolites and the author of many papers on Palæozoic stratigraphy; the Lyell Medal to Mr. E. Greenly, whose long awaited memoir on Anglesey we hope will soon see the light; the Wollaston Fund to Captain W. B. R. King, late of the Geological Survey and now Assistant to the Woodwardian Professor at Cambridge, whose geological work on the Western front has lately been mentioned in our pages; the Murchison Fund to Dr. D. Woolacott, a recent and valued contributor to this Magazine, who has specialized on the geology of North-Eastern England; while the Lyell Fund is divided between Dr. J. D. Falconer and Mr. E. S. Pinfold, who have in recent years been working in Nigeria and India respectively.

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At a recent sitting of the Non-Ferrous Mining Committee of the Board of Trade some interesting evidence was given with regard to the present position and prospects of lead and zinc mining in the Halkyn district of Flintshire. Most of the mines in the district have now been worked almost down to the level of the existing drainage tunnel, and working below this is obviously impossible, owing to the great volumes of water running through the Carboniferous Limestone, as the writer can testify from recent experience underground in that region. A large scheme is on foot for a drainage tunnel at or near sea-level, which would unwater a considerable additional depth of rich veins. Such an undertaking is as a rule too large for any single company to tackle successfully, but there seems to be no possible doubt that judicious co-operation assisted by a subsidy from public funds would result in great developments in this district, where the veins are undoubtedly very rich and mining in the past has been very successful. The recent rise in the price of the metals concerned foreshadows a promising future for this interesting area, if the difficulties alluded to above can be successfully overcome, and there seems to be every possible reason why a

far-sighted and public-spirited policy should here be put into action. It seems possible that the great resources of underground water in Flintshire might even be profitably utilized for the generation of electric power to supply the rapidly growing industrial districts along the estuary of the Dee, and so assist to conserve the coal resources of that part of the country.

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At a special meeting of the Council of the Mineralogical Society on January 20 it was resolved to commence immediately the publication of a series of Mineralogical Abstracts. These will be issued as a separately paged appendix with future numbers of the *Mineralogical Magazine*, which it is hoped will be published at more frequent intervals. It is also proposed to place the Abstracts on sale separately. The name of the author, full title, as in the original, and an intelligible reference will be quoted, thus serving at the same time as a bibliography or catalogue of scientific papers and books, which will be fully indexed. The Abstracts themselves will be brief (200–250 words), though giving as much detail of original matter as possible, but in the case of longer papers and books no more than the nature of the contents can be indicated. It is hoped to include not only all papers and books dealing with purely scientific mineralogy and crystallography, but also to call attention to matters of mineralogical interest in original papers bearing more on petrology, ore-deposits, and economics. The Mineralogical Society being only a small society, the work of abstracting must be carried on by voluntary helpers. It is proposed to allot groups to workers interested in different branches, and to collect their abstracts in batches under suitable headings, e.g. New Minerals, Crystal-structure and X-rays, Optical Methods in Crystallography, Rock-forming Minerals, Meteorites, Ore-deposits, etc. Anybody willing to co-operate in this work, or desirous of joining the Society, will be welcomed. Authors can assist in the search for material suitable for abstraction by sending reprints of their papers to the editor, L. J. Spencer, Natural History Museum, S.W. 7.

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The Council of the Geological Society of London has made the following recommendations for the election of officers for the ensuing year: President, Mr. R. D. Oldham; Vice-Presidents, Professor E. J. Garwood, Mr. G. W. Lamplugh, Col. H. G. Lyons, and Professor J. E. Marr. No changes are proposed in the offices of Secretary and Treasurer. The following members of the Council retire: Sir J. Cadman, Dr. C. W. Andrews, Dr. G. Hickling, Sir J. J. H. Teall, and Mr. S. H. Warren. The following are recommended for election as ordinary members of the Council: Professor W. S. Boulton, Professor O. T. Jones, Mr. R. G. Carruthers, Capt. W. B. R. King, and Lieut.-Col. W. Campbell Smith.

ORIGINAL ARTICLES.

On an Inverted Mass of Upper Cretaceous Strata near Leighton Buzzard, Bedfordshire; and on an Overlap of the Upper Gault in that Neighbourhood.

By F. L. Kitchin, M.A., Ph.D., and J. Pringle, F.G.S.

(*Continued from p. 15.*)

B. Comparison with other Sections in the District.

I. *Sections near Leighton Buzzard.*

We owe to Mr. Lamplugh a description of the lowest beds of the Gault and their junction with the Lower Greensand, as seen in sand-pits on the south side of Leighton Buzzard.[1] Mr. Lamplugh proved the presence of the fauna of the *mammillatus* zone and found that the fossils preserved in the gritty phosphatic nodules of the lowest bed above the false-bedded sands include *Douvilleiceras mammillatum* (Schloth.) and the characteristic *Desmoceras* usually associated with it.[2]

In May of last year an excellent section, comprising Lower Greensand and Lower Gault, was shown in a sand-pit (Mr. Webster's) about 200 yards south of Billington Crossing (No. 1) on the Leighton Buzzard–Dunstable railway (L. & N.W.R.). This old excavation was reopened at the end of 1918 and has now been abandoned. At the time of our visits the beds exposed were as follows:—

		ft.	in.
	Soil	1	0
Gault with *interruptus* fauna	Greenish-grey stiff lumpy clay with a few smooth skinned nodules. Numerous fragments of ammonites of the *interruptus*-type occur mainly in the form of casts . . . about	4	0
	Brownish sandy clay with streaks of glauconite .	1–2	0
	Thin band of dark-grey clay		2–3
Passage-bed to Gault, with *tardefurcata* fauna	Dark-brown well-bedded sandy clay with numerous rounded quartz-grains and pebbles. Pale-coated dark gritty phosphatic nodules of irregular shape (up to 6 inches in diameter), their surface studded with quartz-grains, occur sporadically throughout . . . . . about	4	0
Lower Greensand	Dirty brownish-white false-bedded sand with bands and masses of iron-grit in lowest 5 feet. Numerous thin brown rusty streaks occur parallel to bedding-planes; the sand paler in colour at the top . . . . seen to	9	0

[1] G. W. Lamplugh, "Report of an Excursion to Leighton Buzzard": Proc. Geol. Assoc., vol. xxvi, pt. v, 1915, p. 310.

[2] Specimens of the *Desmoceras* were submitted to one of the present writers and were identified by him; but he is not responsible for the name under which they were cited in Mr. Lamplugh's report (op. cit., p. 310). For a further account of the species see A. J. Jukes-Browne, *The Cretaceous Rocks of Britain*, vol. i, "The Gault and Upper Greensand of England" (Mem. Geol. Surv.), 1900, p. 443; also G. W. Lamplugh & F. L. Kitchin, *On the Mesozoic Rocks in some of the Coal Explorations in Kent* (Mem. Geol. Surv.), 1911, p. 100.

A similar but less complete section of the beds overlying the Lower Greensand is to be seen at the eastern end of the sand-pit on the north side of the level-crossing (No. 2).

The following are some of the fossils collected by us from the *tardefurcata* bed of these two pits: all, with the exception of a single specimen of the *Desmoceras*, found half-way up in the bed, were encased in the rough-coated nodules.

Terebratula sp.
Exogyra conica ? (J. Sow.).
Panopea sp.
Pecten (*Syncyclonema*) *orbicularis* J. Sow.
P. (*Neithia*) sp.
Desmoceras aff. *beudanti* (Brongn.).
Douvilleiceras mammillatum (Schloth.).
Leymeriella regularis (Brug.).
L. tardefurcata (d'Orb.).
Sonneratia dutempleana (d'Orb.).

The most significant of these fossils are the species of *Leymeriella* and *Sonneratia*, which have hitherto not been recorded from any locality in this country. These or other species of the *Leymeriella*-fauna[1] mark a definite zonal subdivision in certain districts on the Continent (Ardennes, South-Eastern France, and Brunswick),[2] occurring in association with *Douvilleiceras mammillatum*, but marking a time-period prior to the introduction of the *interruptus*-fauna. The *mammillatus* bed at Folkestone, as in the neighbouring part of France, contains elements of the *interruptus*-fauna, but no specimen of *Leymeriella* has been recorded from it. It therefore seems highly probable that the zonal representation is imperfect in that region, and we may conclude that the passage from Lower Greensand to Gault is more clearly demonstrated at Leighton Buzzard than at any exposure in England hitherto described. We think it not unlikely that the sandy basement-bed of the Gault at West Dereham, Norfolk,[3] would also yield the *tardefurcata*-fauna if it were thoroughly searched. Jukes-Browne's description of the lowest Gault at Clophill,[4] east of Ampthill, conveys the same suggestion.

It should be noted that no specimen of *Belemnites minimus* or of any ammonite of the *interruptus*-type was found in the *tardefurcata* bed, while in the higher part of the section not one of

[1] For figures and descriptions see C. Jacob, "Étude sur quelques Ammonites du Crétacé Moyen": Mém. Soc. Géol. France, Paléontologie, No. 38, 1907, pp. 53–8, pls. vii, viii.

[2] C. Jacob, "Études Paléontologiques et Stratigraphiques sur la Partie Moyenne des Terrains Crétacés dans les Alpes Françaises et les Régions voisines": Trav. Laboratoire de Géologie de la Faculté des Sciences de l'Université de Grenoble, vol. viii, fasc. ii, 1908, pp. 296–7. W. Kilian, *Lethea Geognostica*, II. Das Mesozoicum, Bd. iii, Abth. i, "Unterkreide," Lief. i, 1907, p. 62. G. Müller, "Beitrag zur Kenntniss der Unteren Kreide im Herzogthum Braunschweig": Jahrb. k. preuss. geol. Landesanst. für 1895, vol. xvi, p. 110, Berlin, 1896.

[3] J. J. H. Teall, "The Potton and Wicken Phosphatic Deposits" (Sedgwick Prize Essay), 1875, pp. 20–2. A. J. Jukes-Browne, *The Cretaceous Rocks of Britain*, vol. i, "The Gault and Upper Greensand of England" (Mem. Geol. Surv.), 1900, p. 297.

[4] Op. cit., p. 285.

the ammonites recorded in the above list was seen. Many ammonites were found in this upper bed of clay, chiefly in the form of fragmentary casts; but every one was a *Hoplites* of the *interruptus*-type. Several species are represented, and it is unnecessary for our present purpose to attempt to name them critically. They display no greater diversity than is seen among a number of distinct species determined alike as *Hoplites interruptus* (Brongn.) in the chief public collections. *Belemnites minimus* List. also occurred, and among the few imperfect lamellibranchs found we recognized *Plicatula gurgitis* Pict. & Roux.

We believe that an almost complete passage from Lower Greensand to Lower Gault is shown here. Although the dividing-line between the Lower Greensand and the *tardefurcata* bed is clearly marked, and has been described by Mr. Lamplugh as a "sharp junction", there is no appearance of any considerable break in the series. The contrast lies in the change from the cross-bedded character of the sands below to the horizontal bedding, with accession of the clay-constituent, in the overlying bed. This might be interpreted as merely proclaiming a somewhat rapid transition to more tranquil conditions of sedimentation. At Miletree Farm (No. 8), however, the *tardefurcata* bed with gritty phosphatic nodules is separated from the top of the cross-bedded Lower Greensand by a 6 ft. bed of horizontally stratified fine sand of distinctive character, indicating that there is probably a true stratal break at Webster's Pit, though not one of any considerable magnitude.

A comparison between the section at Webster's Pit and that in Harris's Pit at Shenley Hill thus demonstrates how strikingly they are contrasted in all essential particulars. In the neighbourhood of Billington Crossing there is no sign of the beds C to G of Shenley Hill; that is, the brachiopod bed, the basal Upper Gault, the ironstone-bands, and the impure sands overlying the "silver-sands". The lithological development of the Gault Clay in the two sections is so different as alone to cast doubt on the identity of these beds: while a study of the fossils proves that no correlation of any part of the Gault in the two localities is possible.

II. *Sections near Shenley Hill.*

Sections in the neighbourhood of Shenley Hill show that there, also, the relations between the Lower Greensand and the Gault are different from those seen at Billington Crossing.[1] Only at one locality, a pit on the north side of Miletree Farm (No. 8), have we found the *tardefurcata* bed above the false-bedded Lower Greensand. In the same remarkable section the Upper Gault is seen to rest discordantly upon these earlier beds. Farther to the west, the Upper Gault,

[1] The difference was remarked upon by Jukes-Browne, who pointed out that south of Leighton Buzzard there is a gradual passage down to Lower Greensand, while in this more northerly development there is not. *The Cretaceous Rocks of Britain*, vol. i, "The Gault and Upper Greensand of England" (Mem. Geol. Surv.), 1900, p. 284.

with a well-marked basement-bed, overlaps on to the current-bedded Lower Greensand.

At the present time development is proceeding actively in the sand-workings of this neighbourhood. New openings are being made and progress in excavation is so quick, both in these and in older pits, that new geological information is made available within a short interval of time. The stratigraphical relationships show rapid lateral changes in this vicinity, owing to the Upper Gault transgression and the active erosion which accompanied it. For these reasons the detailed description of a section studied on a given date may not be strictly applicable in the same pit at a later time.

The following was the section seen in October last towards the southern end of the western face in the pit north of Miletree Farm (No. 8):—

		ft.	in.
	Soil and subsoil	3	0
Passage-beds to Gault, with *tardefurcata* nodules.	Brown and mottled sand with thin hardened calcareous streaks along the bedding; the top 6 inches with many pebbles and rounded grit-grains	3	0
	Crowded flat pale-brown horizontally disposed claystone-nodules, containing minute traces of plants and with external films of secondary limonite		6
	Pale-brown sand with rounded quartz-grains and small pebbles, darker in hue in lowest 2 feet; and with a few sporadic, partly indurated sand-nodules and pale-coated dark gritty phosphatic nodules	4	6
Lower Greensand.	Horizontally bedded fine sands with streaks of black clayey sand, dirty "silver-sand", and thin layers of brown iron-stained sand; lignite associated with the black clayey layers; a few inconstant brown ferruginous indurated courses, 2 inches in thickness	6	0
	False-bedded white sands, iron-stained in places, with occasional scraps of lignite; seen to .	18	0

The *tardefurcata* bed is here separated from the false-bedded Lower Greensand by a well-characterized 6 ft. deposit of sand, many layers of which are peculiar by reason of their very fine smooth texture and by the alternation of lighter streaks and dark carbonaceous and clayey streaks. We recognized at once that this bed shows a striking resemblance to the fine, similarly impure, sand of bed G in Harris's Pit.

The overlying stratum may be correlated with the *tardefurcata* bed of Billington Crossing. We could not break open a sufficient number of the nodules to enable us to obtain any of the characteristic ammonites, although a few other fossils were found;[1] but the nodules themselves are identical in character with those found at Webster's

[1] While working at Billington Crossing we estimated that the yield of ammonite specimens in relation to the number of nodules broken open is considerably less than 1 per cent.

Pit and in the exposure near to it where this bed was seen. They have the same pale exteriors, roughened by protruding quartz-grains, and the fractured surfaces of their interior parts show the same dark, compact, hard ground-mass of phosphatic material enclosing rounded quartz-grains and rusty specks. The overlying 6 in. bed of claystone-nodules and the 3 ft. bed of sand at the top of the section are developments not seen at Billington Crossing. The series above the false-bedded sands is thus a fuller one at Miletree Farm, but the variation shown is just what might be expected to occur under the conditions which prevailed prior to the deposition of the deeper-water *interruptus* clay.

Towards the northern end of the western face in the same pit (No. 8) the whole of the above series of horizontal sandy beds becomes cut off obliquely by a mass of Upper Gault, showing a well-marked basement-bed sloping down towards the north (Fig. 3). The following is the section as examined at an easily accessible spot, indicated by an arrow on the figure :—

		ft.	in.
	Soil with a few subangular flints . . .		6
Upper Gault Clay.	Lowest clay of Upper Gault, containing small white calcareous nodules (up to 1 inch in diameter)	4	0
Basal bed of Upper Gault.	Impure yellowish-brown earthy sand with some admixture of clay and many rounded quartz-pebbles (up to ½ in. in diameter), and with some white nodules as in clay above ; also brecciated fragments of ironstone and smooth rounded hollow pebbles of ironstone ; an undulating 2 in. limonite ironstone-band (of secondary origin) at base and a similar band at and near the top, the two often broken and dislocated, sometimes approaching each other and becoming confluent ; also thin, irregular interlacing branches of tabular ironstone within the bed ; varying from 4 inches to	1	4
	its undulating lower surface resting unconformably on the tardefurcata bed and underlying sands, as seen in previously described section in the same pit.		

While the original constituents of the basement-bed of the Upper Gault include angular and subangular fragments of limonitic ironstone and many worn hollow pebbles of ironstone, mostly hæmatitic, the thin tabular limonite-bands are evidently of later introduction. They show dislocation and contortion, due to movements in the bed subsequent to their formation.

When traced towards the north within this pit the Upper Gault eventually cuts across lower and lower strata, until it comes in contact with the current-bedded sands at the bottom of the pit. Where this relation is shown, as in the northern face of the pit, the clay above the basement-bed is present to a thickness of about 8 feet, the slope of the ground-surface reducing what would otherwise have been a thicker mass of this clay. The basement-bed and the clay above, which dip towards the east in this face of the pit, are

relatively unfossiliferous. The fact that they are both characterized by conspicuous small white nodules (white throughout) is a point to be specially noted, since, owing to the rarity of fossils, the presence of these nodules is helpful in identifying these beds in other sections. *Kingena lima* (Defr.) and a few poorly preserved remains of other brachiopods were found by us in the basement-bed here, but only *Belemnites minimus* List. was seen in the clay above. The characters of the clay, which are constant wherever these beds occur around Shenley Hill, will be noted below in our account of a section in the abandoned Garside's Pit (No. 4), adjacent to Harris's Pit.

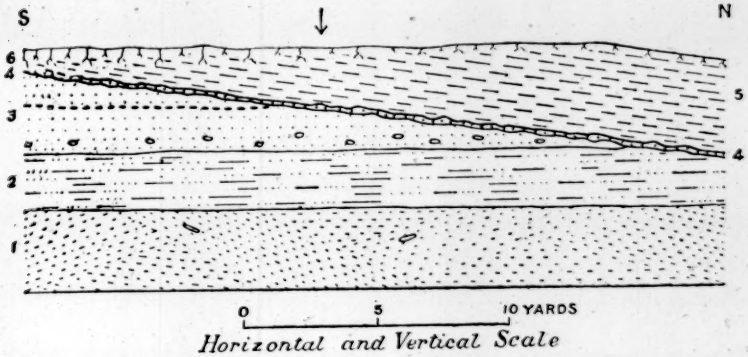

FIG. 3.—Diagram of the section in the western face of the sand-pit on the north side of Miletree Farm (No. 8).

6. Soil.

5. Upper Gault Clay.

4. Basement-bed of Upper Gault, coarse material with thin bands of secondary ironstone; resting unconformably on the Lower Greensand and Passage-bed.

3. Passage-bed between Lower Greensand and Lower Gault; of *tardefurcata*-age. A few dark phosphatic nodules and some partly indurated sand-nodules occur scattered in the lower portion; there is a line of clay-stone nodules above the middle.

2. Horizontally bedded Lower Greensand; fine sand with clayey and carbonaceous layers.

1. False-bedded Lower Greensand, not all shown in the Figure.

The age of the clay cannot be determined at Miletree Farm, where its higher and more fossiliferous part is not present. Information obtained at a section where a fuller development of it is displayed (No. 9) shows that it must be ascribed to the Upper Gault. We have nowhere seen any exclusively Lower Gault fossil in it.

The relatively steep north-easterly dip of the clay and basement bed shown on the north side of Miletree Farm is probably of quite local significance, and is due to the fact that these beds rest on an eroded slope of older strata. The occurrence of a rapid lateral change is shown in the pit situated just south of the farm (No. 7), where the relations of the Upper Gault to the underlying beds are

indeed surprisingly different. The 6 ft. bed of fine horizontally bedded Lower Greensand and the 8 ft. bed of passage strata overlying it, seen north of the farm, are absent. In the northern face of this southern pit the Upper Gault rests directly upon the false-bedded Lower Greensand. The peculiar basement-bed of the northern pit is present here, but is separated from the underlying current-bedded sands by one foot or so of obscurely bedded rather dingy grey-brown pebbly and gritty sand with polished grains. This contains some of the characteristic phosphatic nodules of the *tardefurcata* bed, seen in place north of the farm. This thin deposit of sand is evidently a product of the denudation of the *tardefurcata* bed (see Fig. 3), which is situated at a higher level. Its position just above the false-bedded sands, as well as the presence in it of the small white nodules which characterize the basal beds of the Upper Gault here, shows that it belongs to the period of the transgression. The clay above the basement-bed is present to the extent of 4 feet in thickness. It contains the small white nodules, but differs from the corresponding clay seen north of the farm by the presence in its lower part of numerous highly polished quartz-pebbles, up to half an inch in diameter.

At the west side of pit No. 7, the lowest clay of the Upper Gault is overlain by some imperfectly bedded, crumbled, grey clay, which is met with in other sections about to be described. At the southern end of the pit the false-bedded Lower Greensand crops out at the surface, and no Gault is present. The grey clay just mentioned, which overlies the lowest 4 feet of Upper Gault Clay, is of a peculiar type and is readily recognizable in the other sections where it has been seen. It is a soft clay without any well-defined bedding-planes, and is made up of innumerable small pellets, which are for the most part somewhat angular in shape. It might be termed a finely brecciated clay. We think it most probable that the material of which it is composed is the redeposited débris resulting from the denudation of some previously formed, well-consolidated clay. It is relatively unfossiliferous, and appears to contain no ammonites. Here and there it contains small pockets of glauconite, with some of which a few specimens of *Belemnites minimus* List. are associated.

It is evident that at Miletree Farm the upper beds of the Lower Greensand, with the passage-beds at the top, were subjected to erosion under the action of strong currents. They stood up here on the sea-floor as a bank of consolidated, though soft, horizontal strata, the sloping sides of which were being planed away. While the fine, lighter material of the 6 ft. bed of sand underlying the *tardefurcata* bed would, under such conditions, be swept away by currents, some of the nodules and heavier sandy materials of the *tardefurcata* bed found their way down the slope and, as a residue of the local denudation, formed a constituent of the basal deposit of the Upper Gault. An almost identical section, showing the rearranged sand 1 foot thick (with nodules from the *tardefurcata*

bed) at the base of the Upper Gault, resting immediately upon the false-bedded Lower Greensand, is situated in an opening recently made just north of Sandpit Cottages (No. 10). In a neighbouring abandoned working 200 yards north-west of Sandpit Cottages and about 200 yards N.N.E. of Harris's Pit (No. 6), the thin sand-bed with derived nodules is not present at the base of the Upper Gault; the basal bed of mixed composition rests directly on the false-bedded Lower Greensand.

In the large abandoned Garside's Pit, the section at the present southern face (No. 4), at a point about 150 yards S.S.E. of Harris's Pit, is as follows:—

		ft.	in.
	Soil and Drift	1–3	0
Upper Gault Clay.	Crumbled or finely brecciated grey clay, imperfectly bedded, with small brown-skinned and black nodules (up to 1 inch in diameter), and occasional small pockets of glauconite; *Belemnites minimus* found throughout, but abundant near top; small *Inoceramus concentricus* rare; no other fossils seen . . . about	6	0
	Grey and brownish clay, better laminated than the above, with small white calcareous nodules (up to 1 inch in diameter); only *Belemnites minimus* seen; the bottom 1–4 inches stained reddish . . . . . about	4	0
	resting conformably upon		
Basal bed of Upper Gault.	Clayey yellow and greenish impure sand with much brecciated material, principally fragments of ironstone (up to 3 inches in diameter); the bed has greenish sandy streaks and contains the same kind of white nodules as in bed above .	8–15	
	Hard limonitic and partly vitreous iron-grit, forming a continuous band	2–3	
	marking unconformable junction with		
Lower Greensand.	False-bedded sands with large irregular indurated masses of iron-grit towards upper part and at top, sometimes confluent with the iron-grit layer above; sands stained bright orange and reddish-brown below . . seen to about	15	0

The lateral variation in the current-bedded sands of the Lower Greensand, both in respect to induration and colour, is so rapid and frequent throughout the district that there need be no hesitation in correlating the upper part of the sands here with the corresponding purer sands at the neighbouring Harris's Pit. When we come to consider the overlying strata, a comparison between these two sections shows that the sandy beds F and G of Mr. Lamplugh's table of strata at Harris's Pit are unrepresented in the series described above. The lenticles of brachiopod-limestone of bed D are also missing here, just as in all the other sections already described. The peculiar basal bed of the Upper Gault, with possibly an occasional trace of the clay lying conformably upon it, supplies the one connecting link. The 18 ft. mass of inverted *rostratus* Gault at Harris's Pit is entirely unrepresented in the above section.

It is necessary to look further before the local correlation of the section in Harris's Pit can be completed. In a long-abandoned pit situated at about 900 yards north-west of that locality and some 300 yards north of Shenley House (No. 9), the Upper Gault Clay is present to a thickness of about 20 feet. Here the lowest beds, as above described in the section at Garside's Pit, were found in similar development overlying the indurated top of the current-bedded Lower Greensand; thus, a basal bed consisting of yellowish-brown and greenish clayey sand with some pebbles (and with ironstone courses), here less than a foot in thickness; the clay above it containing white nodules, red-stained at its base; and the succeeding crumbled and imperfectly bedded grey clay. Above the lowest 8 feet of clay the section is entirely obscured by slips, but at a distance of about 15 feet above the basal bed a pale marly clay with blocky fracture yielded numerous fossils. These include abundant specimens of *Schloenbachia varicosa* (J. de C. Sow.) and a well-keeled *Schloenbachia* similar to one found near the top at Harris's Pit; a *Hoplites* showing a smooth stage in an *auritus*-like stock; another species of the *splendens* type (in the broad sense); *Inoceramus concentricus* Park., and numerous large examples of *Inoceramus sulcatus* Park. This assemblage indicates a position corresponding with Bed IX of Price at Folkestone, and with the clay showing similar lithological and faunal characters at the top of Harris's Pit.

Since the Gault below this fossiliferous bed, at the locality just described, shows such a marked contrast in all its characters to the beds now in corresponding position at Harris's Pit, there are no grounds for correlating them. If the mass of Gault in Harris's Pit were in a normal position this contrast would be difficult to explain. Since we have shown it to be inverted the explanation is simple. The beds there below the clay containing *Inoceramus sulcatus* and *Schloenbachia varicosa* represent a still higher part of the series, of which a portion, only a few feet thick, is present at the top of the section north of Shenley House.

We infer that the Gault *in situ* at Shenley Hill was originally some 40 feet thick at the most; and we consider that the presence of the fauna of Bed IX of Folkestone such a short distance up in the series makes it certain that only the Upper Gault is represented here. This reading of the facts is supported by the ascertained thickness of the formation where it is fully developed farther to the south, even when allowance is made for a general thickening of the sediments in that direction.

The evidence thus shows that the date of the overlap may well coincide approximately with that of the Middle Junction Bed (VIII) at Folkestone. The character of the lowest bed is such as would result from its formation upon a sandy bottom in shallow water under the action of relatively strong currents. The transgression would imply a deepening of the sea-floor, so that these

coarser sediments soon gave place to the succeeding clay. Locally, as we have noted at one of the pits at Miletree Farm, the clay immediately above the bottom bed contains pebbles, a sign of continued current-action at that spot. Evidence for the existence of an overlap of *interruptus* or later date has been referred to by Dr. A. Morley Davies,[1] while Professor Kilian has pointed out the widespread character of the transgressive movements proved to have occurred in Upper Gault time.[2]

Another section in this neighbourhood is less easy to interpret. This is the brick-pit, situated 1,100 yards to the southward of Harris's Pit (No. 3), from which Jukes-Browne recorded a number of Upper Gault and Lower Gault fossils.[3] There was at one time an exposure here showing 10 feet of clay with a seam of nodules about the middle, from which the fossils were said to have been obtained. This pit has long been disused and is now so overgrown and flooded as to give no information. Mr. Lamplugh used Jukes-Browne's account of this exposure in support of the contention that the clay at Harris's Pit above the brachiopod-bed is of Lower Gault age. Indeed, this seems to have been the only item of evidence which he was able to bring forward as the basis of the following important statement: "We must therefore conclude that the overlying clay in the sand-pit sections represents Lower Gault, and that the fauna of the calcareous masses is of earlier date." [4]

Now it is clear that if the fossils recorded in Jukes-Browne's list were correctly identified, the nodule-bed in which they occurred does not belong to the Lower Gault; it must be of *rostratus* age. If the Lower Gault fossils truly came from the same bed of nodules they must have been derived; if they did not come from that stratum, then it is conceivable that beds of *interruptus*-age are present at this locality, overlain by the unconformable *rostratus* Gault. Yet the knowledge gained from the sections already described renders it improbable that a 10 ft. section would include both these faunas. No nodule bed similar to that described by Jukes-Browne has been seen in any of the sections examined by us, and we are unable to test the value of his record. It is possible that the bed is present in the concealed part of the section in the Upper Gault 300 yards north of Shenley House (No. 9); the character of the fossils recorded by Jukes-Browne is quite in keeping with such a position, corresponding with Bed IX at Folkestone.

The examination of the undisturbed Gault east and west of Shenley Hill shows that the higher beds of the Upper Gault, which constitutes the main mass of the hill, stand up as an outlier, isolated

[1] A. M. Davies & J. Pringle, "On two deep Borings at Calvert Station (North Buckinghamshire) and on the Palæozoic Floor north of the Thames": Quart. Journ. Geol. Soc., vol. lxix, pt. ii, 1913, p. 338.

[2] W. Kilian, *Lethea Geognostica*, II. Das Mesozoicum, Bd. iii, Abth. i, "Unterkreide," Lief. i, 1907, pp. 61–125.

[3] A. J. Jukes-Browne, op. cit., 1900, p. 285.

[4] G. W. Lamplugh & J. F. Walker, op. cit., 1903, p. 246.

from the general outcrop of Gault to the east and south-east. In pre-Glacial times the high ground must have been capped by some remnants of the basal Cenomanian bed, as shown by the fossiliferous lenticles preserved at Harris's Pit beneath the inverted mass of *rostratus* Gault.

From the information obtained from the sections above dealt with, as well as from Mr. Lamplugh's published records showing the former occurrence of the brachiopod-lenticles (bed D) in parts of Chance's Pit and Garside's Pit, we can form some idea as to the original size of the overturned mass of strata. A great part of it has been destroyed in the course of the excavations, so that at the present time the remnant is only accessible for study at Harris's Pit. It may be roughly estimated that the mass formerly showed a north and south extension of about 250 yards. The position of its original eastern boundary is more uncertain, but was probably about 150–200 yards distant from the present working face at Harris's Pit (see Fig. 1). It is impossible to say how much further to the west the limit of the mass in that direction might be proved to occur if excavation were to be continued. It is probable that its westerly margin will not be reached in Harris's Pit, a sand-working situated in the slope of the hill with a thickening cover of clay. But the purely local character of the inverted mass has already been sufficiently demonstrated.

(To be concluded.)

On the Quartzite Pebbles of the Oldhaven (Blackheath) Beds of the Southern Part of the London Basin.

By Herbert Arthur Baker, M.Sc., F.G.S.

(PLATE I.)

IT is common knowledge to all geologists interested in the Lower Eocenes of the southern part of the London Basin that, in the Oldhaven (Blackheath) Pebble Beds, pebbles of a brown quartzite are often to be found on searching amongst the rounded flints of which these beds are so largely composed. When geological parties visit sections exposing the pebble-beds of the Lower London Tertiaries, the search for these quartzites usually constitutes one of the items of the field-work to be done. A considerable number of these pebbles must, by this time, have been collected, but, although their occurrence has given rise to a good deal of discussion and speculation, nobody appears, so far, to have undertaken a systematic examination of their characters and petrological affinities. The view has been propounded that the study of these pebbles would throw light on the question of the source of the material composing the Lower London Tertiary beds. In dealing with the

latter question, the difficulty confronting the geologist is that since the pebbles of the Oldhaven Beds consist (except for the quartzites) entirely of rolled flints, and since, where pebble-beds occur in other of the component members of the Lower London Tertiaries, they are always composed of flints, it is naturally inferred that the Chalk was denuded to furnish the material for these strata, but it is obvious that the Chalk alone could not have supplied the arenaceous and argillaceous material composing them. The hope has therefore lingered in the minds of geologists that, sooner or later, the parent-mass of rock from which these quartzites were derived would be located, and evidence concerning the source of the material of the Lower Eocenes be thereby gained.

Dr. G. J. Hinde, in the course of a paper on the Blackheath Pebble Beds of the Addington Hills,[1] referred to these quartzites as follows: "The only exception to the prevalent flint-pebbles which came under my notice were some cake-shaped pebbles of a light-grey quartzite, in form and smoothness of surface very much like the flints, from which, indeed, they could hardly be distinguished until they were broken. These quartzites are very hard and fine-grained. They appear to be rare. The largest I found was about 4½ inches across by 2 inches in thickness (110 by 45 mm.). Judging by the character of the rock, they may have been derived from Palæozoic strata, and it is not easy to account for their presence in these Tertiary pebble-beds, associated as they are with Chalk-flint pebbles exclusively. I am not aware that similar pebbles have been previously recorded in the Blackheath or Oldhaven series, but Professor Prestwich has lately stated that large pebbles of white or light-coloured quartzite, now present in the beds of Westleton shingle, may have been derived indirectly from the shingle-beds of the Woolwich and Reading series, where he has occasionally found them, or they may have come from the quartzites of the Palæozoic rocks of the Ardennes."

In the discussion which has centred round these interesting pebbles (based chiefly on the external characters presented by them), opinion has been divided. Whilst some have been inclined to adopt the view of Hinde and Prestwich, quoted above, that these quartzites may have been derived from Palæozoic rocks, others have considered them to be "sarsens". If it be granted that a sarsen is a rock originally associated with, and derived from, Tertiary strata (not necessarily of Upper Eocene age), then the present writer regards these quartzite pebbles as sarsens, but it is not his intention at this juncture to labour the point, or to embark upon a plenary definition of the term "sarsen". It is here proposed simply to consider these pebbles as pebbles occurring in the Oldhaven (Blackheath) Beds.

With regard to their occurrence, these pebbles are certainly rare,

[1] Hinde, Proc. Geol. Assoc., vol. xi, 1890, p. 467.

but not of such extreme rarity as has been supposed. They are apparently always to be found where the Blackheath Pebble Beds are exposed, if the seeker has succeeded in cultivating the necessary "eye" for their detection, and pursues his search with patient assiduity. The writer has obtained them from the Blackheath Pebble Beds in the neighbourhood of Plumstead Common, and at East Wickham, Bostall Heath, and Eltham. The pits at East Wickham and Bostall Heath have yielded them in considerable number to various workers. Mr. A. L. Leach and Mr. R. H. Chandler have obtained a good many from these two localities. They have also been found at Charlton and Keston. The outliers of the North Downs have yielded them. They have been found at Worms Heath and in the neighbourhood of Caterham. They occur on beaches in the neighbourhood of the outcrop of the Lower London Tertiary beds. The writer has collected them in numbers on the beach near Reculver, not far from Bishopstone Ravine, and also at Shoreham (near Brighton) and at Dovercourt. They do not occur at Pegwell Bay, where the Tertiary cliff-section is in Thanet Beds only.

In external appearance these pebbles bear a fairly close resemblance to pebbles of partially decomposed flint, but they possess certain characteristics which, when well visualized, lead to their ready detection in the field. They vary in size, but are usually not small, and are generally, though not invariably, characterized by a flattened ovoid shape suggestive of their derivation from hardened, tabular masses. They are usually very hard, capable of taking and frequently possessing, a more than ordinary degree of polish. In colour they vary from brown to grey or nearly white, being frequently buff or drab. A common feature is a mottled marking or patchy colour-distribution. Another interesting type sometimes met with exhibits a kind of wavy banding of darker and lighter coloured material, due, apparently, to a tendency towards aggregation of the iron-oxides present in the rock. The texture of the rock, as examined on fractured surfaces with a hand-lens, is usually fine-grained, sometimes markedly so, but there is frequently considerable variation to be seen, often in one and the same specimen. There is often little approach to uniformity, the conversion of the rock from sandstone or grit into quartzite having apparently proceeded irregularly, so that the crystalline appearance of a quartzite is seen only in patches, the remainder of the rock appearing as a fine-grained saccharoidal sandstone. It is this variation in texture owing to the sporadic character of the silicification which frequently imparts a mottled appearance to the external surface of many of the pebbles.

When the rocks are sliced and examined microscopically it is seen that they are not metamorphic rocks at all, in the strict sense of the term. They have not been produced by either contact or regional metamorphism, but fall within the class of rocks resulting

from the operation of what has been termed "atmospheric metamorphism". The rocks are really sandstones or grits which have been cemented as the result of a metasomatic change—the addition of fresh silica as a cementing medium. The name "quartzite", as applied to the rocks, is legitimate by virtue of the definition that a quartzite is a rock composed chiefly of quartz grains with the addition of a quartz cement. Yet, in view of the irregular and inconstant character of the cementation the rock may, with equal propriety, be frequently described as sandstone (where the grains are well rounded) or grit (where the grains have preserved their angularity). It is frequently possible, in different parts of the same slice, to apply the names quartzite, sandstone, and grit with equal justification.

In all the slices examined by the writer no evidence of secondary outgrowth from the quartz-grains was to be observed, and there was no sign of optical continuity between the original grains and the secondary silica. The latter was often amorphous, apparently colloidal, and generally dirty with disseminated iron-oxides. Approach to a quartz-mosaic structure was seen only rarely and locally, and was but imperfectly developed. Where observed, the interlocking grains were of small size, and the feature was apparently developed only in the secondary silica. In the examination of the slices the presence of other minerals such as tourmaline, kyanite, staurolite, zircon, rutile, glauconite, felspar, and iron-oxides was noted. With a view to the further examination of these minerals some of the pebbles were crushed, and minerals possessing a specific gravity of more than 2·80 were isolated by the use of Thoulet's (Sonstadt's) solution. It was then seen that the heavy residue was composed essentially of the assemblage of minerals so characteristic of the heavy residues of the Woolwich and Reading Beds. The writer has recently examined a considerable number of heavy residues from these beds, from various localities on the southern side of the London Basin, and he has found the mineral assemblage to be one of remarkable constancy of character. The number of heavy minerals occurring is not large, but the whole suite is invariably present and the minerals always exhibit the same individual characteristics and occur in the same relative order of abundance. The assemblage of minerals (of specific gravity greater than 2·80) is chiefly characterized by the presence of kyanite, tourmaline, zircon, staurolite, rutile, ilmenite with leucoxene, magnetite, limonite, and glauconite. Others, such as colourless garnet, hæmatite, pyrite, anatase, and very rarely andalusite, occur. With regard to the glauconite, which is always present, no definite idea of its degree of abundance can be arrived at, since the amount of iron present in the mineral appears to vary, and the consequent variability of its specific gravity governs its behaviour in the heavy liquid.

The heavy residues from the quartzite pebbles were precisely

similar to those from the Woolwich and Reading Beds. The same minerals occurred, in the same relative order of abundance and exhibiting the same individual features in each case. No mineral occurred, which had not been noted in the Eocene residues, and, of the specially characteristic minerals of the latter, there was no absentee in the residues from the quartzites. In view of this evidence it would seem that these pebbles are not foreign rocks derived from a distance and incorporated in the pebble-beds, but that they are closely related to the Lower Eocene beds.

In pursuance of this idea it becomes necessary to inquire into the evidence for the occurrence, in the Lower London Tertiary beds, of material similar in character to these pebbles, and at once the much debated "greywethers" or "sarsen-stones" are recalled. Prestwich, as long ago as 1854,[1] dealt in a full and admirable manner with the question of the source of the "Druid Sandstones", and the arguments he brought forward are just as cogent to-day as they were when he wrote. He concluded first, from the then available evidence, that the distribution of these "Druid Sandstones" was more in accordance with the range of the Lower London Tertiaries than with that of the Bagshot Sands. This conclusion has been endorsed by later workers. Prestwich then proceeded to consider the three members of the Lower London Tertiaries separately as possible sources of these sandstone blocks. He discarded the Thanet Sands on the ground that although they often present favourable elements and are occasionally semi-indurated, they are rarely consolidated. In the case of the section at the Reculvers, where the Thanet Beds contain a bed of concretionary sandstone, he pointed out that the sandstone has a calcareous cement, contains no pebbles, and frequently exhibits the impressions of shells; whereas the erratic sandstones of Kent, Bucks, and Wiltshire are neither calcareous nor fossiliferous, and are not uncommonly sub-conglomeratic. He pointed out, further, that the Thanet Sands do not range more than 6 to 10 miles westward of London. He next considered his "Basement-bed of the London Clay", with which at that time (1854) were included the present Oldhaven or Blackheath Beds. He alluded to the facts that the "Basement-bed" presents a very small development westward of London, and that although it often contains concretionary blocks they are almost invariably small, calcareo-argillaceous, and fossiliferous. He then stated his belief that the greater portion of the blocks known as Druid Sandstones, greywethers, sarsen-stones, and puddingstones were derived from the middle division of the Lower London Tertiaries. He admitted that it was very rarely that solidified portions of the strata were found in situ, but stated that the same difficulty occurred in as great a degree with the sandstones of the Bagshot Sands. He was able, nevertheless, to put

[1] Prestwich, "The Woolwich and Reading Series": Quart. Journ. Geol. Soc., vol. x, 1854, pp. 123–30.

forward a certain amount of evidence of the occurrence of sandstone blocks in situ in the Woolwich and Reading Beds, and further supported his view by referring to the definite proof furnished by the cliffs of St. Marguerite, near Dieppe, where a bed of sand underlying the fossiliferous Woolwich fluviatile clays contained in several parts of the section blocks of a white saccharoid concretionary siliceous sandstone, which often contained rolled flint-pebbles and subangular flints.

Mr. Whitaker, in the London memoir,[1] expressed his agreement with the conclusions of Prestwich, but experienced similar difficulty in pointing to definite evidence of sarsen-stones in situ in the Woolwich and Reading Beds. Now, however, the needed evidence is available. Genuine sarsens have been seen in situ in Reading Beds, at Long Valley Wood, near Rickmansworth,[2] and at Nately Scures, Hants.[3] In the London area great difficulty is occasionally caused in sinking through the lower part of the Woolwich and Reading Series by the puddingstones and sarsen-stones, which occur in lenticular masses and offer enormous resistance to the chisels. The sarsen-stone is the less common, but has been met with in the east and north of London.[4] It was encountered in the Tube Railway between King's Cross and the Angel, and also at Gerrard's Cross. When the Rotherhithe Tunnel was made the engineers came upon a very interesting occurrence of sarsen-stone and puddingstone in the Woolwich and Reading Beds. At first a fine, hard sandstone was encountered, and after a considerable length of this had been cut through, the sarsen began to contain small, scattered flint-pebbles. These became larger and more numerous till the rock finally passed into a puddingstone. It did not retain this character further on: patches only were cemented, the rest was loose, thus becoming the normal pebble-bed.[5] It thus appears that the cemented pebble-bed or puddingstone passes laterally into cemented sand or sarsen. Mr. G. Barrow states that, in addition, it may pass either above or below into sarsen, for loose blocks have been found in great numbers containing the junction of the two, the matrix of the puddingstone and the sarsen having exactly the same composition and structure. He states that such blocks are extremely numerous to the west of Great Missenden. Near Cuffley, where the new line of the Great Northern Railway crosses the Cuffley Brook, the puddingstone has been well seen in situ in the Reading Beds.[6] In the Woolwich area local induration of beds by silica is a common phenomenon. It is quite common, for instance, for the bed of

[1] Whitaker, *Geology of London* (Mem. Geol. Surv.), vol. i, 1889, p. 479.
[2] Hopkinson, *Middlesex and Hertfordshire* (Jub. Vol. Geol. Assoc.), pt. i, 1909, p. 46.
[3] Proc. Geol. Assoc., vol. xxii, pt. iv, 1911, p. 242.
[4] *Records of London Wells* (Mem. Geol. Surv.), 1913, p. 7.
[5] Barrow, Proc. Geol. Assoc., vol. xxx, pt. i, 1919, pp. 5-6.
[6] Proc. Geol. Assoc., vol. xxv, pt. i, 1914, pp. 77-8.

Ostrea bellovacina in the Woolwich Series to be encountered in a silicified condition. This has been well seen in borings at Woolwich Arsenal, and also at Well Hall, near Eltham. The cementation of this bed is, however, frequently ferruginous in character. The same is true of the indurated masses so often seen in the Blackheath Pebble Beds of this district. At the large brick-pit at South Bromley patches of flint-pebbles cemented in a siliceous matrix have been seen in pebble-beds separated from the London Clay above by about 20 feet of sands, clays, and pebble-beds,[1] but it appears to be much more usual to find that where the Blackheath Pebble Beds are locally cemented into conglomerate, the cement is largely ferruginous in character. Such was the case, for instance, at the Kidbrooke Tunnel.[2] On Plumstead Common, near the bandstand, is a large mass of Blackheath Pebble Beds (an outcast mass from some very old gravel-pits, now vanished) firmly cemented into a hard puddingstone by a cement which is apparently more ferruginous than siliceous.

On the Continent, in Belgium, and North France, sarsen-stones are of common occurrence in the beds equivalent to our Woolwich and Reading Series. Mr. L. D. Stamp, who has recently familiarized himself with the Eocene sequence in these areas, informs the writer that the occurrence of sarsen-stones in the fluviatile facies of the Upper Landenian of Belgium and the Sparnacian of the Paris Basin is a characteristic feature.

At the present time it appears that results afforded by inquiry along three independent lines now point to a common conclusion. In the first place, as the result of the search for evidence concerning the origin of the sarsen-stones, it may now be taken as satisfactorily established that the Woolwich and Reading Beds have afforded one source of supply. Secondly, study of the petrology of the sarsen-stones has revealed a close affinity between them and the material of the Woolwich and Reading Beds. This question has been investigated by Professor P. G. H. Boswell,[3] who found the mineral suite of the sarsen-stones to be precisely similar to that of the Reading Beds, and who concluded that the distribution, mineral constitution, and general characters of the sarsens indicates their probable derivation from the sands of the Reading Beds. Thirdly, as indicated above, the mineral suite of the quartzite-pebbles of the Oldhaven Beds points to a close affinity between them and the sands of the Woolwich and Reading Beds. All that now appears to be required is some definite piece of evidence indicating a direct connexion of the sarsen-stones with the Oldhaven quartzites, and a recent fortunate find of the writer's apparently affords the necessary connecting-link. The photograph shown in the Plate (Fig. 1) is of a rolled quartzite-pebble which the writer obtained in situ in

[1] Summary of Progress Geol. Surv., 1913, p. 29.
[2] T. V. Holmes, Proc. Geol. Assoc., vol. viii, 1893–4, p. 154.
[3] Boswell, Quart. Journ. Geol. Soc., vol. lxxi, 1915, pp. 573–4.

Blackheath Pebble Beds exposed in a road-cutting on the eastern side of Plumstead Common. In addition to showing all the usual features of these quartzite-pebbles, the present specimen is specially interesting in virtue of the fact that it contains within itself a large number of rolled flint-pebbles. Numbers of the latter were exposed on the exterior of the pebble, and on fracturing it many more were seen. Slices were prepared for microscopic examination, and were cut so as to include some of the flints. Two microphotographs of these sections are shown (Figs. 2 and 3). The amount of cementing material seen in these slices is less than was seen in sections of other quartzite pebbles (as mentioned above, variation in the amount of cement is characteristic of these rocks), and there is a closer approach to a quartz-mosaic structure, but in other respects all the usual features are exhibited. One point, however, is worthy of mention. In addition to the flint-pebbles, rolled quartz-pebbles were also present. These ranged in size up to about $\frac{1}{2}$ in. in diameter. Fortunately some were cut through in the slices, so that it was possible to determine by microscopic examination that they were quartz-pebbles and not altered flint. The point is of interest since the recorded instances of the occurrence of quartz-pebbles in the Reading Beds are few. Mr. H. J. Osborne White has stated that the occurrence of these pebbles at the base of the Reading Beds is by no means rare, but they appear to have been recorded only from Long Valley Wood, near Rickmansworth, Lane End, Nettlebed Hill, and near Chalfont St. Giles.[1]

The above evidence definitely fixes the age of this quartzite-pebble (and presumably the others) as post-Cretaceous and not younger than the Oldhaven (Blackheath) Beds. The pebble presents the typical flattened ovoid shape and is particularly well rolled. As is well known, the rounding of the pebbles in the Blackheath Pebble Beds is of a very thorough character—in the typical exposures a subangular flint is unknown. The character of the beds suggests that their deposition occupied no great length of time—the time required for the rolling of the pebbles was probably great in comparison. That is to say, the rolling of the pebbles probably preceded their deposition as the Blackheath Pebble Beds. A well-marked plane of erosion separates the Pebble Beds from the underlying Woolwich and Reading Beds, and sections showing "scoops", where the Pebble Beds are seen to rest on low members of the Woolwich and Reading Series or sometimes to cut completely through them and rest on the Thanet Sand, are of common occurrence. It would appear that during this pre-Oldhaven erosion of the Woolwich and Reading Beds, large numbers of flints and occasional sarsen-stones were removed from them, subjected to a great amount of rolling, under conditions which did not, as a rule, permit of the decomposition of the pebbles, whereby the rounding of the latter was perfected, and that finally the pebbles

[1] Proc. Geol. Assoc., vol. xxi, 1909–10, p. 245 (with further references).

were deposited, in no great length of time, to form the Blackheath Pebble Beds.

From this point of view we may regard the occurrence of these rolled quartzite-pebbles in the Blackheath Beds as additional evidence of the pre-Oldhaven erosion of the Woolwich and Reading Beds.

It is somewhat singular that Prestwich, in the classical series of papers on the strata between the London Clay and the Chalk, appears never to have suggested the possibility of these quartzite-pebbles of the pebble beds being rolled fragments of sarsen-stone. He knew of their occurrence in the pebble-beds, for he stated that he had occasionally found them in situ, and suggested that the similar pebbles of the Westleton Beds may have been derived from the Lower London Tertiaries. He pointed out their difference from the quartzites of the Triassic conglomerates, but suggested the possibility of their having been derived from the Palæozoic quartzites of the Ardennes. The point is the more remarkable inasmuch as Prestwich, in amassing strong evidence in favour of the Woolwich and Reading Beds having been one (and possibly the chief) source of supply of the sarsens and puddingstones, was at pains to emphasize the fact that the pebble beds overlying the Woolwich and Reading Series rest upon a strongly eroded surface of the latter beds, and are themselves derived in great part from the destruction of the lower beds.

Summarizing, in conclusion, the main points put forward in the present communication, the writer contends that without attempting to dogmatize upon the question of the scope and applicability of the term "sarsen", but employing it in the general sense now permitted by usage, as free from the limitations some would impose, the following points may now be regarded as established :—

(1) The sarsen-stones and puddingstones considered here are cemented portions of sandy and pebbly Lower Eocene strata.

(2) The Woolwich and Reading Beds have afforded one source of supply of these stones.

(3) The pebbles of quartzite and siliceous flint-conglomerate occurring in the Oldhaven (Blackheath) Beds are rolled fragments of sarsen and puddingstone derived from the Woolwich and Reading Beds.

EXPLANATION OF PLATE I.

Fig. 1.—Rolled quartzite pebble from the Oldhaven (Blackheath) Pebble Beds. Road cutting east of Plumstead Common. Four-sevenths full size. The quartzite contains rolled pebbles and broken fragments of black flint. Note flint pebble $\frac{3}{8}$ in. long showing on surface of quartzite at left-hand end of photograph. The quartzite also contains rolled pebbles of white quartz.

Fig. 2.—Section of pebble shown in Fig. 1, showing flint. Ordinary light. Magnified six diameters.

Fig. 3.—Section of pebble shown in Fig. 1, showing flint; quartz-grains rather closely packed, not much cement. Crossed nicols. Magnified eighteen diameters.

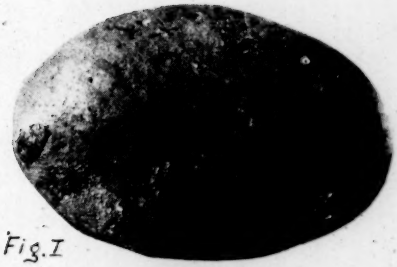

Fig. I

Fig. II

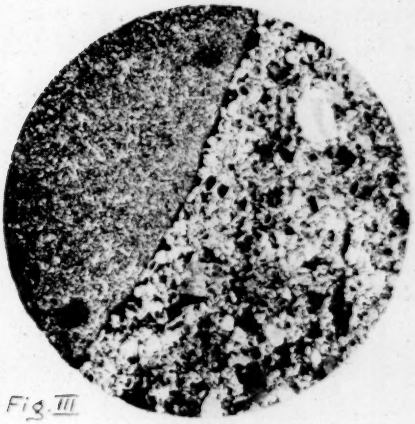

Fig. III

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Quartzite Pebbles of the Oldhaven Beds.

(To face page 20

The Chines and Cliffs of Bournemouth.

By Henry Bury, F.G.S.

I. The Chines.

THE country round Bournemouth consists of a wedge-shaped plateau, lying between the River Stour and the sea, and ranging roughly from 100 to 200 feet above sea-level. Of the numerous valleys which intersect it, those that join the Stour present as a rule no special features, but most of those running down to the sea are of exceptional character and are known as chines—a term which does not admit of very accurate definition, but is generally applied only to valleys of more than usual steepness.

It is somewhat remarkable that, although the Geological Survey has published two editions of its memoir on Bournemouth,[1] in neither of them is any attempt made to deal with either the form or the origin of these chines. Several other writers, however, have noticed them, and have made suggestions as to their origin; Lyell,[2] for example, thought that they originated as the result of landslips, though he does not attempt any details of the process or explain how the country was drained before they arose. Mr. Starkie Gardner[3] considered them as simply enlargements of the innumerable furrows cut by the rain in the cliff-face, and even speaks of new chines being formed in the course of a few days; while Dr. Ord[4] takes practically the same view, for after describing in detail the formation of these cliff-furrows, he adds: "These illustrate the first step in the formation of our chines." It is clear, then, that while these three authors differ somewhat in detail they are all agreed in regarding these valleys as having started in comparatively recent times in the face of the cliff, and having lengthened themselves by growing rapidly inland. But although a few of the minor indentations of the cliffs may possibly have been formed in this way, yet with regard to all the principal chines—all, at least, that are named as such in the 6 in. map of the Ordnance Survey—there are strong reasons for doubting whether this hypothesis is correct.

In the first place, if the chines are actually growing longer, their rate of growth must be greater than that of the recession of the cliffs; and since the latter is known to be in the neighbourhood of a foot a year, the heads of the chines should exhibit signs of very great activity. Now a rough measure of such activity can be obtained; first, from the angle of slope, which is far less at the heads of the chines than in the cliffs; and secondly, from a study of the vegetation. The face of the cliff is so steep and is

[1] *The Geology of the Country round Bournemouth*, 1st edition, 1898; 2nd edition, 1917.

[2] *Principles of Geology*, 10th ed., vol. i, 1867, p. 533.

[3] Quart. Journ. Geol. Soc., vol. xxxv, 1879, p. 220.

[4] *The Natural History of Bournemouth and District*, 1914, pp. 61, 321.

changing so rapidly that plants have no chance of establishing themselves on it, and the same is true of the mouths of the chines, where readjustment to the changing coastline is constantly going on; but the heads of all the principal chines are (or were before man interfered) covered with rank vegetation, and afford no evidence at all of rapid erosion.

Secondly, the form of the chines must be taken into consideration. If we examine the valley of the Bourne (not usually accounted a "chine") we find the sides rather steep, but the bottom wide and fairly flat; in fact, in section it has the form of a broad letter U. In Durley Chine, on the other hand, the sides are exceedingly steep and the bottom narrow, so that a section takes the form of a V. Passing next to Branksome Chine (or Branksome Glen [1]) we find both these forms represented, the upper portion of the valley (i.e. that furthest inland) being wholly of the U type, while the lower (from just above All Saints Church down to the sea) has a V-shaped ravine carved in the floor of the U (Fig. 1). Clearly, then, we have two valleys of different ages, a newer and steeper one

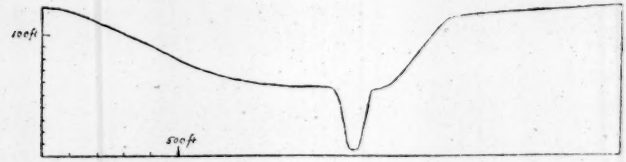


Fig. 1.—Transverse section of Branksome Chine.

which alone contains water, and an older one which is more than twice as wide and as long, being traceable inland almost as far as Parkstone Station, where it is truncated by the slope leading down to Poole Harbour; while at the other end, after forming a well-marked terrace on each side of the newer valley, it ends somewhat abruptly about 50 feet above sea-level. It is, in truth, a hanging valley, but its relation to the cliff is obscured partly by alterations due to man, and partly by the fact that it curves towards the east at this point, and was formerly continued for some distance in that direction almost parallel to the present cliff. The latter is exceptionally low opposite Branksome Tower Hotel [2] for this very reason, namely, that it is here a section of the old valley floor (valley gravel, though not shown on the geological map, can be seen capping it), and not, as elsewhere, a section of the plateau (Fig. 2). This double structure can be traced in all the principal chines of Bournemouth Bay, as well as in the "Bunnies" of Christchurch Bay.[3]

[1] The latter name is used by Mr. Starkie Gardner, the former by the Ordnance Survey, by which what used to be known as "Branksome Chine" is called "Branksome Dene Chine".

[2] See Mem. Geol. Surv., *Bournemouth*, 2nd ed., p. 23, fig. 5.

[3] Quart. Journ. Geol. Soc., vol. xxvi, 1870, p. 532.

but is absent from the so-called "Bottoms" which run down to the Stour and the Avon. In Boscombe Chine, as in Branksome Glen, the older valley is deep and comparatively long; but in the shorter chines (Alum, Durley, etc.) the remnant of the old valley is so shallow and extends so little beyond the head of the newer one, as to be easily overlooked (Fig. 3), especially as its natural form has been much altered by the hand of man. It can, however, still be easily traced by slight changes in the gradients of the roads (Western Road, West Cliff Road, etc.), as well as, here and there, by terrace-like fragments of the old valley floors. In the valley of the Bourne human interference has obliterated almost all traces of this structure, but some (chiefly in the upper parts of the valley) are still visible, while others can be inferred from historical data.

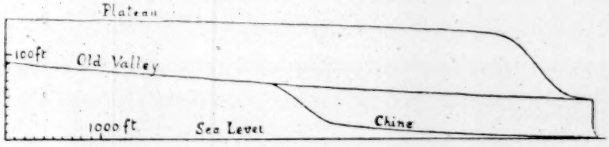


FIG. 2.—Longitudinal section of Branksome Chine.

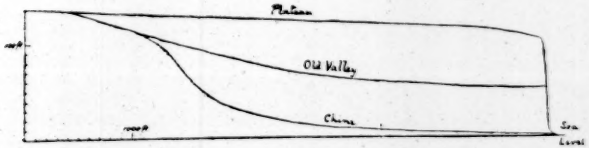


FIG. 3.—Longitudinal section of Alum Chine.

It will be observed that the peculiar structure of the valleys described above is in no way accounted for, or even considered, by the hypotheses hitherto put forward to explain the origin of the chines, and we must therefore look elsewhere for the cause. It will hardly be disputed that the smaller size of the newer valleys (to which alone, as a rule, the name "chine" is applied) is mainly, if not wholly, due to meteorological changes. There may have been in the past a far greater rainfall than now, but having regard to the porous nature of the soil, and the way in which the great width of the old valleys is maintained right up to their points of origin in the plateau, it is probable that they were formed in a period of intense cold, when the ground was rendered impervious by frost. The floors of these valleys are often covered with gravel and cemented sand, and the evidence on the whole seems to point to their having been formed in the time of the Coombe Rock—that being the latest period of intense cold of which we have clear and widespread evidence along our southern coasts.

But we have still to account for the difference in level between the old and the new valleys. If this feature had been common to all the valleys of the district we should have been justified in postulating a change in relative sea-level, and perhaps connecting the old valleys with the well-known raised beaches, rather than with the later period of the Coombe Rock, when the sea had sunk somewhat below its present level. But we have seen that the difference in level is confined to those valleys which run down to the sea, and a little consideration will convince us that, though a change in sea-level is not in itself improbable, the mere encroachment of the sea on the land is quite sufficient to produce the observed phenomena.

There are strong reasons for believing that in former times a river (Solent River) ran across what is now Bournemouth Bay, being cut off from the English Channel by a line of hills connecting the Isles of Wight and Purbeck; and although opinions differ as to the exact time at which its southern boundary was breached by the sea, yet the balance of evidence seems in favour of a fairly late date.[1]

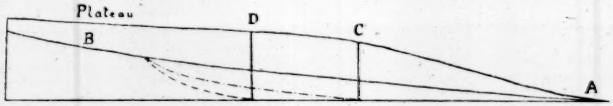


FIG. 4.—Longitudinal section showing the relation of the old and new valleys to the changing shore-line. A, Solent River. B, Floor of old valley. C and D, Successive positions of the cliff, with the floor of the new valley (dotted lines) adjusted to them.

The lateral streams from the Bournemouth district would probably meet this river about one or two miles from the present coast, but the destruction of the river by the sea and the subsequent recession of the coastline have led to a shortening of their valleys and consequent readjustment of the thalweg to new gradients. Owing, however, to the greatly reduced size of the streams, only a short and narrow portion of the old floor was affected, thus giving rise to the chines, as shown diagrammatically in Fig. 4. The same figure also explains how, without any change in sea-level, the remnants of the old valley floor appear at higher and higher levels in the cliffs as the latter recede.

There is, it is true, no direct evidence that the Solent River survived to quite so late a date as is here suggested, but the wide floors of the old valleys must have required time for their formation, and appear to me more consonant with a fixed outfall into a main river than with a shifting one into a constantly encroaching sea—and the conditions are such as to render a stationary coastline highly improbable. Moreover, while it seems certain that chines,

[1] Mem. Geol. Surv., *Bournemouth*, 2nd ed., 1917, p. 48.

both here and in the Isle of Wight,[1] are due to the advance of the sea, I see no evidence of that advance in earlier structures.

The difference between the hypothesis supported by Lyell and others and that here advanced may be summed up as follows: According to the former the chines originated in quite recent times as miniature torrents in the cliff-face, and have since been growing steadily longer and less steep (longitudinally); while in my view, although the chines themselves (reserving this term for the newer valleys) are recent, yet they are the remnants of an old drainage system which anteceded the cliffs; and since the growth at the head is, if not absent, at any rate less rapid than the advance of the sea, they must each year be growing shorter, and will (unless marine erosion is permanently checked by man) ultimately disappear altogether.

II. The Cliffs

The suggestion (first advanced, I believe, by Mr. Carus Wilson) that there has been a general increase in the steepness of the Bournemouth cliffs in the last thirty or forty years, has been widely accepted, and coupling this belief with a tradition of a marshy tract of shore, Dr. Ord[2] builds up an elaborate theory of an old sea-cliff left far inland at the time of the raised beaches, and only recently reached again by the sea. But before we accept such a speculative view we must be absolutely sure of the facts on which it rests.

As there is nothing to show that the marshy tract was anything more than an extension of the valley floor of the Bourne,[3] and as it in any case admits of a simple explanation,[4] it need not be further discussed; but the alleged change in the angle of the cliffs merits closer attention.

My own intimate acquaintance with the western part of the bay (from Alum Chine to Poole Harbour) goes back fifty years, and rests further upon many conversations with one who had been familiar with that coast for some ten or fifteen years before; and I am quite confident that, at any rate within the region named and the time specified, the general angle of the cliffs has undergone no change whatever. Moreover, Lyell, who visited this coast in 1830, evidently found erosion going on rapidly, since, as we have seen, he attributes the origin of the chines to falls of the cliffs. On the other hand, the evidence in favour of change having occurred appears to me to amount to nothing more than this, that *at certain points* the cliffs were formerly more easily scaled than now, and for this, I think, local causes can be found without postulating a wide stretch of raised beach, which is entirely unsupported by evidence.

We have seen that the chines are growing shorter, and from the condition of a few of them (notably Little Durley Chine) we may

[1] Quart. Journ. Geol. Soc., vol. xxvi, 1870, p. 541.
[2] *Natural History of Bournemouth*, pp. 234–5.
[3] Lyell, op. cit., vol. ii, p. 531.
[4] Mem. Geol. Surv., *Bournemouth*, 2nd ed., p. 66.

safely infer that some of their lateral branches have already been obliterated. But the normal angle of the head of a chine is less than that of the cliff, and therefore there will come a time when all that is left of the former is an indentation of the line of the cliff, somewhat less steep than the latter; and if, as happens in more than one instance, the chine ran parallel with the cliff, this diminished steepness might extend for a considerable distance. This I believe to be the true explanation of some at least of the observations on which Dr. Ord and others have relied, but it is not improbable that immediately to the east of the pier another cause may also have been at work.

The ordinary gradient of the beach is greater than that of such a valley as the Bourne, and even at low water it is rare for more than 100 yards of shore to be exposed. But it is evident from Lyell's account of the submerged forest that in 1830 a very different gradient obtained opposite the Bourne, for he describes it as situated 200 yards from the mouth of that valley and as lying between the beach and a bar of sand about 200 yards off. Such a diminished gradient is easily accounted for as the result of the resistance of the peat in which the forest grew to the action of the waves and tides; but the effect of it would probably be to form a sort of groin, which might (since the beach materials normally travel from west to east) afford a good deal of protection to the cliffs on the Boscombe side of the Bourne, and give them time to assume a very moderate slope compared with other parts of the coast. For many years, however, the submerged forest has been seldom visible,[1] and there has been no such decreased gradient opposite the Bourne. This has once more exposed the cliffs to the full force of marine erosion, and in this way we may perhaps account not only for the changes in gradient, but also for the alleged special activity of this erosion between Bournemouth and Boscombe.[2]

Quartzose Conglomerate at Caldon Low, Staffordshire.

By F. Barke, F.G.S., Wheelton Hind, M.D., B.S., F.R.C.S., and A. Scott, M.A., D.Sc.

In the Geological Magazine for February, 1919, J. W. Jackson and W. E. Alkins[3] described the occurrence of a quartzose conglomerate at Caldon Low, Staffordshire. In August one of us (F. B.)[4] pointed out some previous references to this outcrop. The curious and ambiguous reply by Messrs. Jackson and Alkins[5]

[1] The peat does not seem to have been broken up, but to have sunk down, which goes far to support Lyell's contention that in this particular case the submergence of the forest is due more to undermining of the peat than to any general change in sea-level.

[2] *Natural History of Bournemouth*, p. 63.

[3] Geol. Mag., Vol. LVI, 1919, p. 59.

[4] Ibid., p. 384.

[5] Ibid., p. 430.

to this letter necessitates a detailed and accurate description of the history and present condition of the exposure. This reply was particularly ungracious, since one of us in December, 1918, immediately after the reading of Mr. Jackson's first paper at Manchester on the subject, had communicated to him the fact that this quartzose conglomerate had been known to local geologists for many years, and had been shown to the members of the Geologists' Association during the excursion to North Staffordshire in 1890.

To settle finally the position of the quarry which we propose to discuss, and which is the same quarry as that described by Jackson and Alkins, its longitude is 1° 53′ 10″ W. and latitude 53° 2′ 20″ N., and the height is about 900 feet above O.D.

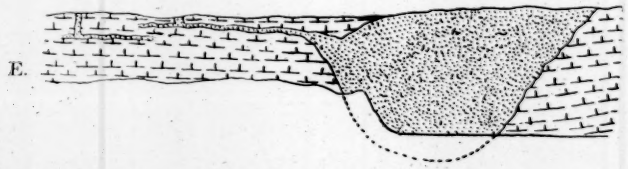
Previous History.—In an address delivered in 1873, Wardle [1] mentions the existence of a sand and clay deposit at Caldon Low, and this pit was first visited by two of us in 1889. It was then in part a sand- and clay-pit of the type which is found in the Weaver Hills, with pockets of sand and clay in the centre and masses of conglomerate at the edge. It was very briefly mentioned in the report [2] of the visit of the Geologists' Association in 1890, but no one could be blamed for not recognizing the spot described. However, this was remedied by J. A. Howe in his paper,[3] "Notes on the Pockets of Sand and Clay in the Limestone of Derbyshire and Staffordshire." In 1905 the North Staffordshire Railway Co. began to extend their quarries northwards, and, clearing away the small pocket of sand and clay, laid bare a basin-shaped mass of quartzose conglomerate in which they drove a small siding in an eastward direction. This fact was noted in the report of the Geological Section of the North Staffordshire Field Club.[4]

Present Condition of Exposure.—At the present time the quartzose material is being rapidly quarried away, and on both north and south faces of the cutting the actual junction of the conglomerate with the undisturbed and well-bedded limestones, which here form a low anticlinal, the northern limb dipping north at an angle of 20°, can be clearly seen. The contact which forms the western boundary of the conglomerate can be traced on both sides of the cutting from the top of the quarry faces to the floor, the angle of inclination being variable, but averaging about 50° to 60°. In the centre the bottom of the deposit is not visible, as it passes under the floor of the cutting. Near the junction the quartzose material shows vertical bedding and is much more conglomeratic than towards the centre.

At the eastern end of the cutting the contact with normal limestone also rises quickly, but not to the top of the face, as a thin bed of conglomerate about 1 foot thick, with a bed of crinoids above it and normal limestone below, is seen to pass eastwards. On tracing

[1] North Staffordshire Field Club: Addresses, Papers, etc., 1875, p. 34.
[2] Proc. Geol. Assoc., vol. xi, 1890, p. 130.
[3] Trans. North Staffordshire Field Club, vol. xxxi, 1897, p. 143.
[4] Ibid., vol. xl, 1906, p. 85; vol. liii, 1919, p. 101.

this bed, which, although fairly level, does not always maintain the same stratigraphical horizon, it suddenly rises to the top of the quarry by a vertical pipe 2 or 3 feet in diameter. A little further east another pipe of conglomerate comes down from the top and connects with another thin bed at a lower level than that a few yards away. As a whole, the field relations suggest that the conglomerate fills a subterranean hole in the limestone, probably formed by solution, the thin beds representing several underground watercourses leading into the main hollow. The question of a contemporary deposit of quartz conglomerate does not, therefore, arise, and there is no connexion with the quartz-pebbles in beds of D_2 age at Castleton.



Diagrammatic section (E.–W.) showing the quartzose conglomerate (dotted) at Caldon Low. The uppermost line represents the top and the lowest line the bottom of present exposure.

The occurrence of fossils in the conglomerate is interesting. The fauna at once strikes one as a D_2 assemblage and quite different from and having nothing in common with the fauna of the Caldon Low Limestones. We consider that the fossils are all derived, because, first, the fauna of the conglomerate is a mixed one; secondly, examination of thin sections shows a shattering of the fossils, many of them being in a fragmentary condition; thirdly, the typical fine-grained limestone of Caldon Low is found in angular blocks in the conglomerate. These blocks are very much larger than any of the other detrital materials, and this, together with their unrolled condition, suggests that they have fallen from the sides or the roof of the subterranean hollow. Mr. Howe [1] mentions the fact that a block of Pendleside shale, containing *Posidoniella minor*, was found by one of us in the clay-pit formerly on this site.

The horizon of the Caldon Low Beds may be definitely assigned to the base of the Viséan. The fauna is a very limited one and exactly similar to the homotaxial equivalents of the Clitheroe and Belgian provinces. *Caninia* should occur near this horizon. Brachiopods are limited to *Productus humerosus*, *Chonetes papilionacea*, C_1 form, and *Orthotetes* aff. *crenistria*, C_1 form. Corals are represented by a very small form of *Syringopora*, gasteropoda by very large species of *Naticopsis*, *Bellerophon cornuarietis*, and other species of this genus. A fragment of a large *Myalina* is the only pelecypod which has been obtained.

[1] Loc. cit., p. 144.

On comparing the above with the list given by Messrs. Jackson and Alkins, it will be noted that the fauna of the conglomerate is quite a different one, and is indicative of a much higher horizon. Beete Jukes was evidently correct when, in 1839, in a section across North Staffordshire in his paper, "Sketch of the Geology of Derbyshire,"[1] he shows the beds at the base of Caldon Low to be fairly low down in the series.

Petrography of the Conglomerate.—The pebbles in the conglomerate vary greatly in size and in number, and comprise many rock types. The largest are the angular and subangular blocks of grey Caldon Low limestone, while smaller but rounded fragments of the same material are common. In general the material of finer grain is decidedly water-rolled. So far as distribution is concerned, the marginal portions of the conglomerate are much less rich in pebbles than the interior, but even in the latter the proportion of visible detrital material varies from place to place. In addition to the rock containing large limestone fragments, several distinct types of conglomerate can be distinguished; first, a rock containing numerous pebbles, up to an inch or two in diameter, with relatively little matrix; secondly, a similar but more fine-grained rock; and thirdly, a very fine-grained limestone, with abundant minute fragments of quartzose material. The pebbles include fragments of grey Caldon Low limestone, fossiliferous limestone, several types of quartz rocks, cherts, shales, Lydian stone, and some altered igneous material.

Several specimens of the conglomerate and the normal Caldon limestones have been sectioned and examined microscopically. The ordinary Caldon Low limestone shows no trace of quartzose material, and is composed mainly of organic remains, including brachiopod shells, crinoid stems, fragments of corals, tests of foraminifera, etc., in a matrix which is apparently structureless, and was probably a calcareous mud originally. Crystalline calcite, apart from veins and joints, is conspicuously absent. The larger fragments of limestone in the conglomerate are very similar.

The coarse quartzose conglomerate consists of several types of rocks and organic fragments cemented together by relatively large crystals of calcite. The shells and other calcareous materials are obviously fragmental, and the lack of internal structure and optical homogeneity of many fragments suggest that recrystallization has occurred. Often the calcite of the matrix has crystallized round the detrital limestone in such a way as to be optically continuous with it. Pieces of dolomitized material and oolitic grains can also be seen.

Several types of quartz-rock are present. Vein-quartz occurs commonly, each piece being optically homogeneous except for the presence of strain shadows, which are sometimes so prominent and so orientated as to indicate that the material has undergone

[1] *Analyst*, vol. ix, 1839, p. 2.

considerable pressure. This effect is very similar to the one commonly observed in Bunter pebbles. In one specimen of the conglomerate the detrital material is mainly vein-quartz, and practically every pebble shows decided traces of the effect of pressure. The occurrence of this rock, with such a large proportion of vein-quartz, is interesting, as bands of similar material can be observed in some of the sand- and clay-pits near Friden, Derbyshire.

In many specimens the pieces of vein-quartz, although originally of a rounded form, have invariably a marginal development of secondary quartz in optical continuity with the original grain, and possessing perfect external crystal forms. The latter are so sharply defined as to make it practically certain that the secondary growth has occurred in situ, as even slight rolling would have reduced to some extent the perfection of the faces. The presence of secondary growths on quartz has been noticed by Howe [1] in the material from the Ribden Pit.

A pebble of equigranular quartzite, with relatively large interlocking quartz crystals and little visible cementing material, has a decidedly metamorphic aspect, and is probably derived from pre-Cambrian or early Palæozoic deposits. Several types of sandstone which closely resemble some of the Carboniferous rocks of the Midlands are also present. A fine-grained sandstone, which is made up of subangular grains of quartz with subordinate felspar in a siliceous matrix of quartz and colourless mica, is very like some of the local rocks of Millstone Grit age, which have been used for refractory purposes, while other rocks, which can also be matched among the local deposits of the same age, included a coarse sandstone with rounded quartz crystals and scarce felspar in a cement of secondary quartz, and a fine-grained siliceous conglomerate, consisting of fragments of rounded vein-quartz, quartzite, sandstone, and shale in a matrix of secondary quartz and mica. These rocks resemble closely the so-called "ganisters" of the Stockton Brook district.

Another rock which has angular to subangular quartz grains with little or no felspar, set in a mosaic of interlocking crystals of very fine secondary quartz, closely resembles some of the crowstones of the Pendleside Series which occur in the neighbourhood of Congleton. Other equigranular rocks, consisting almost entirely of quartz, with wavy extinction, and thin interstitial layers of cement, are suggestive of the ganisters of the Lower Coal-measures.

Several fragments referable to chert can also be recognized, and others of very fine grain appear to be indurated quartzose shales. The igneous rocks include tuffs, etc., as well as felsites with a decidedly aphanitic texture.

With regard to the proportions of the various rock-types, the fragments of quartz rock far exceed the others in amount, and of these the sandstones and "crowstones" preponderate over the

[1] Loc. cit., p. 146.

others, except in the bands which are largely composed of vein-quartz. The metamorphic quartzites are relatively subordinate. Many of the quartzite pebbles appear to be derived from local rocks of Pendleside, Millstone Grit, and, possibly, Lower Coal-measures age, while the limestone fragments, according to the fossil contents, are derived from beds ranging from the Caldon Low limestones to D_2 rocks.

On an average the amount of calcium carbonate in the conglomerate does not exceed 20 per cent, and of this at least half belongs to the crystalline matrix. Hence the amount of primary detrital limestone is less than 10 per cent, compared with 85–95 per cent in the normal Caldon Low limestone. The cherts possibly originated in the deposits of that material in the D_2 and Pendleside Beds of Derbyshire. An almost identical lithological assemblage is found in the Bunter beds which occur at a height of 814 feet above O.D. at High Shutt, about 4 miles to the south-west.

The Weaver Sand-pits.—An examination of the sand- and clay-pit south of Ribden Mine, about 1 mile from Caldon Low, gives much help in elucidating the problem of the Caldon Low conglomerate. This large, open pit, which is about 900 feet above O.D., is worked for sand and clay, the former being predominant. It contains pockets of uncemented pebbles, similar in character to those at Caldon Low, but here and there consolidation has occurred, and we find hard masses of quartzose conglomerate like great sarsens, and very similar lithologically to the infilling at Caldon Low. Nowhere are the limestone sides of the pocket to be seen, but the limestone outcrops all round the deposit. In the pit fairly large pebbles, 2 to 3 inches in diameter, are to be seen, and these are typically pitted like the Bunter pebbles. We have observed similar pebbles at the former clay-pit at Caldon Low and in the Derbyshire sand-pits near Newhaven. Moreover, the lithological assemblage at Ribden is essentially Bunter, and very similar to the deposits of the latter at High Shutt.

The sand deposits at Ribden and elsewhere and the conglomerate at Caldon Low have thus many points in common: (*a*) There is a close lithological similarity between the constituent materials; (*b*) each contain a local concentration of vein-quartz pebbles of intermediate size; (*c*) each contain deposits of fine sand; (*d*) in each case the latter shows well-developed secondary outgrowths on the quartz crystals; (*e*) the relative amounts of such materials as Lydian stone are similar. The chief points of difference are the presence of calcareous cement at Caldon Low as compared with the generally unconsolidated nature of the material at Ribden, and the substitution of the large quartzose pebbles at Ribden by the limestone fragments at Caldon Low. The larger blocks have not been transported any great distance, and it is probable that they represent material which has fallen from the sides and roof of the pits; in the one case the sandstone blocks from now denuded

Bunter beds, and in the other the limestone from the roof of Caldon Low limestone.

The lithological examination of the materials of the Caldon Low conglomerate and the sand- and clay-pits of the Weaver Hills and Derbyshire has shown that they are all essentially the same. The deposits in each case were probably laid down by river action, the consolidated nature of the Caldon Low material being due to the fact that the hollow in this case was a subterranean one, dissolved out of the limestone, which would provide the calcium carbonate which forms the cement. So far as the origin of the pebbles is concerned, these include many types of Carboniferous rocks, and, as a whole, are a typical Bunter assemblage; hence it seems feasible to infer that they are derived from deposits of the latter age.

Conclusions.—The quartzose conglomerate at Caldon Low is not a penecontemporaneous bed deposited unconformably on the Caldon Low limestone, but is an infilling of a subterranean hollow and several underground watercourses in the limestone.

The pebbles are derived mainly from Bunter deposits, and have reached their present location at some period between Bunter and Glacial times.

The fossils in the conglomerate are all derived and mainly of D_2 age.

REVIEWS.

FOSSIL PLANTS: A TEXT-BOOK FOR STUDENTS OF BOTANY AND GEOLOGY. By A. C. SEWARD. Vol. IV: Ginkgoales, Coniferales, Gnetales. pp. xvi + 544. 190 illustrations. Cambridge University Press. £1 1*s*.

THE fourth volume, dealing with the remaining portion of the Gymnosperms, brings to a conclusion this important work, of which the first part appeared in 1898. The main bulk of the plant remains of the past has now been dealt with, but the treatment of fossil Angiosperms has been left for future writers, as the author realizes that a reliable summary of our present knowledge of the geological history of the flowering plants would involve an immense amount of labour, and the co-operation of experts in systematic botany. He considers that he is not adequately equipped for this task, and it would seem probable that it will be long before anyone is found to undertake it, unless one of the American palæobotanists steps into the breach.

The whole work has covered the wide and scattered field of palæobotany in a remarkably thorough way, and almost all the important fossil genera have been mentioned or described, both as regards those based on structural material and those formed for impressions. Brief but excellent summaries of the modern plants to which the fossil types are related have been given, and these have been of considerable utility in giving a conception of the nature of the plants which may be represented as fossils by a group of incomplete fragments; they also assist in the explanation of the system of classification employed and indicate what features are of special importance.

In the volume just published a full account of the fossil Ginkgos is given. This is of especial interest to the geologist on account of the widespread occurrence of this group in Mesozoic times, as well as owing to the solitary survivor found to-day in the Maidenhair-tree. It is characteristic of the caution exhibited throughout the work with regard to the multiplication of species, that the first of the 190 illustrations in this volume depicts the varied forms which the leaves of the modern *Ginkgo biloba* may assume. Some palæobotanists consider that Professor Seward is too conservative with regard to species, but it is certainly preferable in a work of this character to keep genera and species united until good grounds can be produced for their separation. For example, in the case of a fossil which is very common on the Yorkshire coast and which often resembles a group of Pine needles, the genus *Czekanowskia* is defined so as to include forms with entire and bifurcated leaves, on account of their similarity in arrangement on short shoots and also because of the close identity of their epidermal structure. Some palæobotanists would separate the forms with entire undivided leaves into the genus *Solenites*, but

though this course has not been followed, the view is mentioned and references are given which will enable the student who is interested to investigate the matter for himself.

Several Palæozoic genera, such as *Psygmophyllum*, which have been assigned by various authors to the Ginkgoales are described, but it is pointed out that the evidence on which this classification is based is wholly inadequate.

A considerable section of the book is devoted to the consideration of fossil coniferous woods, a subject which badly needed summarizing in a broad comprehensive way, and which has also been dealt with by Kraüsel in a current number of *Palæontographica*. The majority of the pre-Tertiary petrified woods are of Coniferous affinities; they are by no means uncommon, but their identification has presented many difficulties in connexion with the characters to be used and in their nomenclature. Several previous authors have dealt with groups of woods of a particular age or from a particular region, but a recent comprehensive summary was lacking. The present descriptions and classification ought to be of great assistance to those who wish to determine fossil woods, without making a special study of the recent and fossil forms and reading through the extensive literature on the subject.

The study of fossil coniferous twigs and of the remains of cones has also been greatly assisted by the succeeding chapters. Some forms, such as those from the American Cretaceous had been thoroughly investigated, but a vast mass of unsystematized information existed in botanical and geological literature about other types. The student is invariably puzzled to find Permian twigs described as *Walchia*, while apparently similar types from the Trias are known as *Voltzia* and from the Jurassic as *Pagiophyllum* or *Elatides*. The summaries of the characters of the twigs and cone structures upon which these generic distinctions are founded, will be a great help to both students and investigators, and should assist in standardizing our nomenclature. The examination and criticism of all the evidence by an author who is an enthusiastic student of the recent Coniferæ means a considerable step forward in our knowledge of fossil plants and of the past history of the cone-bearing trees.

The title of student has just been applied to the author of this monumental work, and it is to students in the widest sense of the word that this textbook will appeal. Parts of it will be of great value to the elementary student who is making a first acquaintance with the principal fossil types, but as a whole the work will be invaluable to all who are engaged in a study of the vegetation of past ages. The very copious references to original papers, to discussions, and to the best figures will be of immense help to all who are interested in this great field of knowledge. The list of works referred to in vols. iii and iv which is printed at the close of vol. iv occupies fifty-one pages, and indicates the extent of the literature which has been used in the compilation of this book. There

may be many minor points in which the work is open to criticism from those who belong to different schools of thought. A few palæobotanists may disagree with some of the nomenclature which is used, or others may think that a genus in which they are interested has been too scantily treated. But the fact remains that there are few men who are willing or competent to undertake a task of the magnitude which has now been so ably concluded, and all students of fossil plants owe a considerable debt to the author.

H. H. T.

On the Four Visible Ingredients in Banded Bituminous Coal: Studies in the Composition of Coal No. 1. By Marie C. Stopes, D.Sc., Ph.D. Proc. Roy. Soc. B., vol. xc, 1919, pp. 470–87, with two plates and a text-figure.

In this paper the author proposes an extended scheme of subdivision of the component parts of banded bituminous coal, which comprises terms more precisely defined than those formerly used, viz. : "mineral charcoal," "dull coal," and "bright coal". The new classification is as follows :—

(1) Fusain, "Mineral charcoal" or "Mother of coal".
(2) Durain, "dull coal."
(3) Clarain } "bright coal."
(4) Vitrain }

Of these terms the first has been in use for some time in France, but the last three are new. The ordinary appearance of the first two is well known and needs no comment, but there seems to have been considerable confusion in the past as to what exactly "bright coal" is, some authors using the term in its broad sense and others confining it to vitrain. Vitrain is a very brilliantly reflecting and apparently homogeneous substance, with a conchoidal fracture, and occurs generally as small lenses and thin streaks in the clarain. Though the durain and clarain are predominant in the dull and bright layers respectively, these layers are rarely pure, and the dull layers generally contain thin streaks of clarain and the bright layers enclose streaks of durain. Vitrain, however, is always pure and shows no sign of banding.

These four substances behave differently under both chemical and microscopic examination. If pieces of them be placed in the dark on a photographic plate the most intense image is obtained from vitrain, one less intense from clarain, while that given by durain is fainter still. Alcoholic potash causes vitrain to swell and become soft, so that sections can be cut from it with a razor, but makes the other three substances friable. Treatment with strong nitric acid containing a few drops of hydrochloric acid, followed by neutralization, gives with vitrain a clear liquid of the colour of strong tea with no insoluble residue. Clarain also yields a similarly coloured liquid, but contains some fine-grained insoluble residue.

With durain the insoluble residue is larger and coarser and the solution lighter, while fusain is hardly dissolved at all, and a large fibrous residue is obtained.

In thin sections, also, a graduating change of appearances is noticed ; fusain generally is composed of a mass of black and opaque woody tissue with thickened cell walls and empty cell lumina. Durain consists of a black, opaque, granular groundmass enclosing yellow spore coats. Clarain is clear, coloured red and yellow, and abounds with plant structures of all kinds, while vitrain is also yellow and translucent, but without any trace of organic structure.

The paper is illustrated by two plates, one in colours, showing very clearly the difference in the thin sections of the four subdivisions, and in the solutions obtained from them, and also by a text-figure in which their distribution in typical sections of coal is shown by conventional stippling.

W. H. W.

Crystallization-Differentiation in Igneous Magmas. By N. L. Bowen. *Journal of Geology*, vol. xxvii, 1919, pp. 393–430.

READERS of Anatole France's *La Rotisserie de la Reine Pédauque* will remember that M. d'Astarac, having once conceived the notion that sylphs and salamanders have a present-day existence, found no difficulty in explaining quite ordinary happenings in the light of his extraordinary conception. Similarly, though happily his notion rests on foundations more secure than did M. d'Astarac's, Dr. Bowen has no difficulty in explaining all petrological happenings in the light of his crystallization-differentiation conception. In both cases one can observe the same wholehearted devotion to a charming conception, but also the same neglect of the more obvious deductions.

Dr. Bowen criticizes Daly's views on syntexis and maintains that assimilation plays but a minor part in differentiation, for, even though complete abyssal assimilation be admitted, the problem of the splitting of the resultant syntectic magma is still one of separation of phases. He also combats the limestone-syntectic hypothesis of the origin of the alkaline rocks.

In dealing with liquid immiscibility in differentiation, Dr. Bowen considers that this factor is of no importance whatever. He deduces that a blotchy or patchy separation of phases must follow from liquid immiscibility, and from the general absence of this patchiness in natural igneous rocks he concludes that this factor is not operative. In opposition to this conclusion one must point out that the common occurrence of patchy differentiation in quartz-dolerite sills in Scotland has led to the view that liquid immiscibility may sometimes be a most important factor (Glasgow Memoir, p. 148).

Again, Dr. Bowen considers that abrupt transition would not be expected on the immiscibility theory, since an emulsion would result. Where immiscibility has been claimed in Mull as yielding differentiates *in place* perfect transitions occur (Summary of Progress for 1913, pp. 48, 49, 51). Of course, transition may be expected on any theory of gravitational differentiation.

Using the Duluth lopolith as an example, Dr. Bowen discusses the gabbro-granophyre association and claims that this discontinuous variation can be explained by the mechanical straining off of the mother liquor (granophyre) from the already solidified crystals (gabbro) under the influence of pressure. This mechanism is, of course, well known in Britain, though its advocacy by Mr. George Barrow nearly thirty years ago in relation to certain intrusions in the East Highlands (GEOL. MAG., 1892, p. 64, and Quart. Journ. Geol. Soc., 1893, p. 330).

Dr. Bowen's suggestion (p. 417) that banding of gabbros and peridotites is not a form of flow-structure will scarcely receive credence. Here the likeness of Dr. Bowen to M d'Astarac becomes especially close. He believes that banding is a reaction to mechanical stress on a crystal mesh with still fluid matrix, and that the stress tends to give rise to cavities into which the matrix exudes, while the crystal mesh above and below packs. One can scarcely doubt that such an origin would show itself in an orientation of the early minerals with their axes perpendicular to the exudation bands which they border. One has only to look on a large surface of a banded rock—especially of a porphyritic banded rock—to perceive that the mechanism evoked by Bowen has not operated, but that true flow has occurred. Moreover, Dr. Bowen's explanation, on his own theory, would apply only to an ultrabasic rock banded with more acid rock and not to the very common case in which gabbros, for instance, are banded with scarcer ultrabasic layers.

Dr. Bowen discusses the origin of nodules and schlieren in igneous rocks, and considers them to be due to crystal jams resultant from the packing together of crystals at constricted points and their subsequent removal and partial resorption in the main body of the magma. Such filter presses, required here and elsewhere by Dr. Bowen, have been found to be quite unworkable when copied in industrial processes.

This paper must be welcomed chiefly because it will rouse claimants of liquid immiscibility to renewed exertions. There is little, if any, tendency on this side of the water to rule out either settling of crystals (postulated seventy years ago by Darwin) or mechanical straining (postulated thirty years ago by Barrow) as factors in differentiation, but there is a tendency, perhaps a growing one, amongst field-workers to support the claim that liquid immiscibility is a *vera causa* in addition. Field observations will supply, one believes, the key to differentiation.

H. H. READ.

Palæozoic Worms and Hydroids in Victoria.

F. CHAPMAN (1919, Proc. Roy. Soc. Victoria, vol. xxxi, pp. 315–24, pls. xiii, xiv) claims to have found the gill-plumes of the Silurian worm *Trachyderma*, well preserved in the Melbournian Mudstones near Keilor, Victoria. This evidence confirms the usual reference of the fossil to the Chætopoda, and suggests that it belongs to the Sabelliformia. Mr. Chapman regards *Eotrophonia setigera* E. O. Ulrich, 1879, as similar gill-plumes. This came from the Lower Cincinnatian beds of Covington, Kentucky, not from Cincinnati itself. Mr. Chapman also describes a new Cornulites (*C. youngi*) from Lower Ordovician slates with *Didymograptus caduceus*, on the Moorabool River north-west of Geelong, and claims it as the oldest recorded. On the evidence of a flattened basal attachment, Mr. Chapman believes that this genus as well as *Pteroconus* Hinde (=*Nereitopsis* Green) is a tubicolar Chætopod.

In another paper (tom. cit., pp. 388–93, pls. xix, xx) Mr. Chapman refers some finely preserved specimens from the Lower Palæozoic Lancefield slates to the Hydroid Order Calyptoblastea, under the names *Archæolafoëa* n.g. and *Archæocryptolaria* n.g. He also refers to the same Order the *Chaunagraptus* and *Mastigograptus* of Ruedemann, and describes a new species of the latter as *M. monegettæ*. (See Plate XV in Geological Magazine, December, 1919.) The discovery is an interesting one, for, with doubtful exceptions in the Pleistocene, the only fossils hitherto assigned to this Order are the Dendrograptidæ. Until representatives have been found in the intermediate strata, sceptics will doubt the lineal descent of modern Sertularians and their allies from these ancient forms, however great the external resemblance may be.

A Study of the Brachiopod genus *Platystrophia*. By Eula Davis McEwan. Proc. U.S. National Mus., vol. lvi, 1919, pp. 383–448, pls. 48–52.

THIS is a study of the North American species of the well-known Ordovician and Silurian genus *Platystrophia*, leading to a systematic arrangement based on their supposed evolutionary history. We say "well-known", but, as Miss (or Mrs.) McEwan points out, the determination of the genotype — *Terebratulites biforatus* Schlotheim — is still uncertain. She therefore selects as a new genotype *Platystrophia laticosta* Meek, 1873. This action is surely ill-advised, even if admissible. Two alternative courses are open to a reviser. First to attempt the fixation of the genotype. Schlotheim's description, unaccompanied as it is by a figure, may be unintelligible to a modern palæontologist, but this may only be because of his larger acquaintance with allied forms and his more minute discrimination. Von Buch, we are told, saw the holotype in the Berlin Museum, and had no difficulty in pointing out the

slight differences between it and *Terebratula lynx* Eichwald. If the characters he reported are again rendered inadequate by the advance of knowledge, then surely the obvious course is to re-examine the holotype. Has this been attempted? If the holotype has disappeared, then in any attempt to fix the species regard should be paid to Schlotheim's statement that the unique specimen came "aus dem südlichen Frankreich", though Von Buch thought it more probably came from the North (i.e. the Baltic region). The species has always been regarded as a close ally of *P. lynx*, and it ought to be possible to determine that species with precision. If, however, the attempt to elucidate *P. biforata* be given up, then the alternative course is to select as genotype one of the other species mentioned by King (1850) when he established the genus, namely *Spirifer tcheffkini* De Vern., *Porambonites dentata* and *costata* Pander, and *Spirifer terebratuliformis* M'Coy. None of these is mentioned by Miss McEwan, who prefers to select a species introduced twenty-three years later and found many thousand miles from the type-locality. The fact that Miss McEwan lives in Illinois, or even the fact that American intercourse with Germany has been interrupted for a few years, cannot justify this calm setting aside of all early descriptions and material.

So far as North American species are concerned, Miss McEwan's paper continues the line of research initiated by E. R. Cumings in 1903, when on the basis of characters in the young shell he separated the species into Uniplicate, Biplicate, and Triplicate. In the Uniplicate series the single plication on the sinus and the two on the fold continue through life. The Biplicate series starts with a bifurcation of the plication on the sinus and an intercalated median plication on the fold. According as further bifurcations and intercalations do or do not take place, the series is divided into four sub-groups. In the Triplicate series, to which most North American species belong, the single plication of the sinus persists, but is soon flanked by a plication on each side; the two plications of the fold bifurcate. This series is divided into three sub-groups. In two of them called Low Fold and High Fold, the hinge-line is relatively long and the brephic and early neanic stages are similar; in the former sub-group the low rounded fold persists, and the plications of both fold and sinus remain of nearly the same strength; in the latter subgroup the fold becomes high and compressed in the late neanic stage, and assumes an angular appearance owing to the obsolescence of the lateral plications. The third sub-group does not as yet seem to be very clearly defined, but is constituted for large heavy forms generally similar to the *P. ponderosa* of Foerste, and probably arising at various periods as gerontic forms of Low Fold species.

In the groups as thus defined by brephic and neanic characters Miss McEwan recognizes many cases of parallelism and convergence, and these seem to her to show "that the ancestral species had certain

latent possibilities . . . transmitted to the various groups and subgroups, and expressed in a definite order whenever the appropriate environmental stimulation was present". This definite order in the succession of the morphic stages is represented in a table under the heading "Orthogenesis", but why this somewhat metaphysical term should be used is not apparent, for it is not easy to see how the order could have been any other. Another table shows how well the classification agrees with the known stratigraphical distribution, except as regards the *Ponderosa* group.

We hope that Miss McEwan will continue her studies, and that she will have the opportunity of extending them to European material.

F. A. B.

Block Mountains and a Fossil Denudation Plain in Northern Nelson. By C. A. Cotton, D.Sc., Victoria University College, Wellington. Trans. New Zealand Inst., vol. xlviii, 1915, pp. 59–75.

THIS paper was written prior to "Block Mountains in New Zealand" (by the same author), in which the subject of block mountains is treated more fully.

The district examined here is a very small one, the writer confining his attention to the "Aorere–Gouland Depression" and the "Gouland Downs Depression", but the theories advanced serve as a working hypothesis which gives much assistance in the interpretation of this particular district. It would appear that the relief which the deformed undermass presumably had in some earlier period had been almost entirely destroyed prior to the deposition of the covering strata. After the period of deposition of the covering strata, there occurred strong differential movements which sketched out the broad outlines of the land forms of the present day, led to the formation of many consequent rivers, and inaugurated the cycle of erosion in which the majority of the details of the surface were developed. This is quite a departure from the interpretation given by Bell in his Parapara bulletin, in which he supposes that maturely dissected mountains occupied the area in the period immediately preceding that in which the covering strata were laid down, and the period of deposition was one of only partial submergence.

Preliminary Report on the Economic Geology of Hazelton District, B.C. By J. J. O'Neill. Department of Mines, Geological Survey of Canada, Memoir 110. 1919.

THIS report, though short, is somewhat diffuse. It deals with the mines of an area of 225 square miles, situated 130 miles northeast of Prince Rupert. The region is described as consisting of folded Upper Jurassic sediments with interbedded tuffs and tuff-agglomerates, invaded by batholiths of granodiorite and "small batholiths" and dykes of "granodiorite-porphyry".

The ore deposits are genetically connected with the igneous rocks and occur in veins which are later than the dykes. The lodestuff consists of brecciated material showing two periods of movement and mineralization. The structure of the ores indicates that the earlier mineralization led to the introduction of large amounts of chalcopyrite, with small quantities of gold and molybdenite. Part of the chalcopyrite has replaced secondary actinolite, giving rise to the name "hornblende ore". The later minerals are zinc-blende, tetrahedrite, argentiferous galena, chalcopyrite (in small quantities), with banded quartz and some carbonates.

The relation of the veins to the granodiorite appears to have a direct bearing on the mineral paragenesis. Thus, those veins which occur within the boundaries of the larger igneous masses are characterized by the additional presence of magnetite and hæmatite, and those near the contact by pyrrhotite and arsenopyrite. Magnetite is stated to have preceded the pyrrhotite, as it has been partly replaced by it. Tourmaline also occurs, rarely. A point of interest here brought out is the relation of the two groups of ores, indicating a phase-sequence of mineralizations, separated by an interval of time, during the last stages of consolidation of the igneous rock. The report is illustrated by excellent microphotographs of polished specimens of ores.

AIDS IN PRACTICAL GEOLOGY. By Professor GRENVILLE A. J. COLE, F.R.S., M.R.I.A. Seventh edition. pp. xvi + 431, with coloured frontispiece, 2 plates, and 136 figures. London: Charles Griffin & Co., Ltd. 1918. Price 10*s.* 6*d.*

THIS book was first published nineteen years ago, and it is sufficient testimony to its usefulness that it has now reached a seventh edition. The author has made few changes in the present issue, which does not differ greatly from the third edition; nevertheless, the work is well up-to-date, and such alterations as seemed desirable have been carried out. It is not intended to take the place of an ordinary textbook of geology, but rather to supply an aid to the student working in the field, helping him to interpret what he observes and to determine the character of the specimens he collects, whether they be minerals, rocks, or fossils. It is impossible for a field-geologist to carry his interest very far and to apply his knowledge very closely without some acquaintance with the common types of fossils and of their chronological and evolutionary significance, and the author has done wisely to include an illustrated account of the more important groups of fossil invertebrates. We venture to hope that in a future edition, which should soon be reached, he may add some description of the commoner vertebrate remains, especially such as are found in this country. The work is very appropriately dedicated to the memory of the late Professor Judd.

F. H. A. M.

THE DISTRIBUTION OF ORES OF TUNGSTEN AND TIN IN BURMA. By J. COGGIN BROWN and A. M. HERON. Rec. Geol. Surv. India, vol. l, pt. ii, pp. 101–21, with two plates (maps). 1919.

IN this paper we have at last definite detailed information as to the geological occurrence and relationships of the tungsten and tin lodes of Burma and the neighbouring districts. They extend over an area 720 miles in length, from Byingyi in the Yamethin district, Southern Shan States, to Maliwun in Mergui, in the extreme south. The lodes are closely associated with a very acid granite intruded into the ancient Mergui sediments. Some of the lodes are typical pegmatites and greisens, while others are quartz veins in the narrower sense of the term, but all appear to be of similar magmatic origin. This is supported by the occurrence in places of tourmaline, topaz, and fluorite. The characteristic minerals are arsenopyrite, chalcopyrite, pyrite, molybdenite, native bismuth, and other bismuth ores. At the present time a large proportion of the output of both wolfram and cassiterite concentrates comes from various detrital deposits. Wolfram is rare in true alluvium, but cassiterite is common in places.

Full descriptions are given of the lodes in all the mines, most of which have been inspected by the authors. Hermyingyi is probably at the present time the largest wolfram mine in the world, having produced in 1917 no less than 1,051 tons of concentrates, out of a total of 3,654 tons for the whole district.

REPORT ON A COLLECTION OF CAINOZOIC FOSSILS FROM THE OIL-FIELDS OF PAPUA. By F. CHAPMAN. WITH GEOLOGICAL INTRODUCTION by ARTHUR WADE. Bulletin of the Territory of Papua, No. 5. 18 pp. Melbourne, 1918.

THE oil-bearing strata of Papua skirt the coast on the south-west from Yule Island to the Parari delta. They range, as appears from Mr. Chapman's determinations, from Recent to the base of the Miocene, and below them are some grits, conglomerates, and sandstones, apparently without fossils but with traces of limestone and coal. Mr. Chapman's report is for the present only a list, but as Dr. Wade points out in a most interesting introduction, it is of much importance in working out the classification and tectonics of the strata and in elucidating such wider questions as the relation of Papua to the adjacent land areas.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

December 3, 1919.—Mr. G. W. Lamplugh, F.R.S., President; and, afterwards, Mr. R. D. Oldham, F.R.S., Vice-President, in the chair.

Mr. S. Hazzledine Warren, F.G.S., exhibited and commented on a collection of Neolithic implements from Graig-lwyd, near Penmaenmawr (North Wales).

Professor W. W. Watts, Sc.D., F.R.S., exhibited and described a new geological map of Western Australia, prepared by the Geological Survey of Western Australia, under the direction of Dr. A. Gibb Maitland, F.G.S.

Mr. C. N. Harris, Chairman of the Western Australian Committee of the Institution of Mining and Metallurgy and of the Committee of Repatriation, exhibited a collection of minerals from Western Australia which he had presented to the Imperial College of Science and Technology, and commented chiefly on those of economic interest.

The President (Mr. G. W. Lamplugh) summarized briefly the phenomena presented by the dry-lake areas of Western Australia, illustrating his remarks with lantern-slides lent by the Royal Geographical Society. He also exhibited specimens from Permo-Carboniferous glacial deposits of the Irwin River district (Western Australia).

CORRESPONDENCE.

THE SGURR OF EIGG.

SIR,—Mr. Cunningham-Craig is good enough to read me a lecture upon the importance of field-work and the danger of being misled by theories. Had he read my paper before attacking it, he would have seen that the theory which I took with me to Eigg was the same which he is now defending, and it was the field evidence that forced me to a different conclusion.

He would have learnt, too, that the presence of granite fragments in the agglomerate of Bidein Boidheach is no new discovery, but is recorded both in my paper of 1906 and in the memoir on the "Small Isles". From the same and other sources he might have learnt further that this is not an isolated occurrence. Fragments of both gabbro and granite of Tertiary type are found in numerous volcanic agglomerates in Skye, Rum, Mull, and Arran. These agglomerates belong to a very early part of the volcanic succession, and are themselves invaded by the gabbro and granite of the mountains. The existence of this *earlier* plutonic series—nowhere exposed in

place, unless it be in Central Mull—is familiar to every student of our Tertiary igneous rocks. Whatever be its significance, it disposes effectually of Mr. Craig's argument.

If, without discourtesy, I may play the mentor in my turn, I would hint in conclusion that a little knowledge, when joined to a large measure of assurance, is a dangerous thing.

ALFRED HARKER.

ST. JOHN'S COLLEGE, CAMBRIDGE.
January 12, 1920.

HÆMATITE IN SOUTH WALES.

SIR,—Allow me to correct a misstatement, serious from the economic standpoint, which is contained in the review of "The Hæmatites of the Forest of Dean and South Wales" (Memoirs of the Geological Survey: Special Reports on the Mineral Resources of Great Britain, vol. x) published in the January number of your journal.

The reviewer states that "the author sees no hope for the resuscitation of the mines under present conditions". On the contrary, the memoir under review describes the hæmatite-field of South Wales as a promising area for development. Thus: "In the hæmatite-field of South Wales . . . recent years have witnessed a successful revival of iron-mining, and the ore-fields give considerable promise for future development" (p. 2); and again: "In view of the high grade of the ore, the comparatively large tracts of undeveloped ground, and the successful mining at Llanharry in recent years, it appears not improbable that the district will produce hæmatite on a larger scale in the future than it has done in the past" (p. 65).

As a matter of interest, I may add that new explorations for hæmatite in the Llanharry district, undoubtedly stimulated by the official geological investigation of the area, have already commenced.

Yours faithfully,

T. FRANKLIN SIBLY.

ARMSTRONG COLLEGE, NEWCASTLE-UPON-TYNE.
January 14, 1920.

OBITUARY.

Henry Charles Beasley.

THE late Henry C. Beasley, who died at Liverpool on December 14, 1919, at the ripe age of 83, was best known to geologists for his work in connexion with the Triassic footprints, especially those found in the Keuper beds at Storeton, Cheshire, and other quarries in the Liverpool district. He published a number of papers in the Proceedings of the Liverpool Geological Society recording his observations, and as Secretary of the British Association Committee for

the Investigation of the Fauna and Flora of the Trias of the British Isles, he wrote a series of reports on the footprints for which he proposed a provisional scheme of classification. In 1906 he was awarded the proceeds of the Barlow-Jameson Fund by the Geological Society of London for his geological work in this connexion. He was Secretary of the Liverpool Geological Society from 1890 to 1900, and President for the sessions 1887–9, 1904–6, and again 1908–9, and served as President of the Liverpool Biological Society for 1901–2. His fine collection of footprints was recently purchased by Councillor C. Sydney Jones, M.A., for the Free Public Museum of Liverpool. Mr. Beasley was a most indefatigable and persistent worker at his favourite geological subjects, such work being his relaxation from an active commercial career. His unselfish character and his readiness at all times to assist any fellow-worker endeared him to all who knew him.

W. H.

Francisco Josué Pascasio Moreno.

Born May, 1852. Died December, 1919.

We regret to announce the death of our friend Dr. Francisco P. Moreno, founder and for many years director of the La Plata Museum. Born in Buenos Aires 67 years ago, he was half English, his mother having been the daughter of an English botanist. He was a collector of natural history specimens from his earliest youth, and he soon began an important series of explorations of Patagonia and the region of the Andes, which lasted from 1873 until 1884. His first scientific paper was a description of some prehistoric cemeteries in Patagonia, published in the *Revue d'Anthropologie* in 1874. Three years later he gave his collection to the Argentine Government, who used it for the foundation of the Anthropological and Archæological Museum of Buenos Aires. In 1880 Buenos Aires became the federal capital, and in 1882 the city of La Plata was established to replace it as capital of the province. In 1884 the provincial governor suggested to Dr. Moreno that he should organize a great new museum in La Plata, taking his anthropological collection as a basis. The special desire of his life was thus fulfilled, and he began to work at once, planning the building and arranging for the acquisition of more collections to illustrate the natural history and antiquities of the Argentine Republic. The excavation of the new docks in the Pampa formation near La Plata especially afforded an opportunity for obtaining a fine series of skeletons of the Pleistocene Mammalia. By 1889 the Museum was nearly complete, and in the following year Dr. Moreno began to issue its well-known series of valuable publications. In 1893, and again in 1894, Mr. Richard Lydekker visited the Museum officially to prepare an account of the fossil Mammalia from the Pampa and some earlier formations,